LAKE ENHANCEMENT DIAGNOSTIC / FEASIBILITY STUDY FOR THE WAWASEE AREA WATERSHED

SPONSORED BY:

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Executive Summary

I. EXECUTIVE SUMMARY

A. Objectives of this Study

The Wawasee Area Watershed Lake Enhancement Diagnostic/Feasibility Study is not an academic study for the sake of studying lakes. This study is a results oriented project. Its purpose is to diagnose ailments, prescribe the most feasible cures, and be a guide to ultimately carry out the implementation of watershed treatment.

Our project objectives are to:

1. Examine the overall health of area lakes and streams and the conditions of their watersheds.

2. Identify existing and potential threats to the water quality of area lakes.

3. Prepare a long term management plan or preventive maintenance plan designed to be a plan of action for future activities to preserve existing lake water quality and the integrity of the watershed ecosystem.

B. The Condition of Other Indiana Lakes.

To put the information that follows in this study on the Wawasee Area Watershed (WAW) into perspective we first need to briefly mention the condition of other Indiana lakes. Most lakes in Indiana are presently suffering the effects of water pollution from a variety of sources. They are becoming increasingly eutrophic.

Eutrophication is basically an overloading of nutrients to water body. Often this nutrient enrichment is associated with substantial sediment loading to the water body.

A result of nutrient overloading is a predominance of nuisance weed growth, nuisance algae growth, poor fishing, poor water clarity, periodic foul odors, high bacteria counts, and general impaired use. Advanced cases usually result in a decrease in the suitability of the lake to support healthy gamefish populations and can even result in fish kills.

Eutrophication is a natural process that is experienced by all lakes. However, the natural rate of eutrophication is very slow, on the order of the geologic time scale. Cultural eutrophication, on the other hand, is eutrophication resulting from the activities of humans, primarily how we manage the land within a watershed. The symptoms of cultural eutrophication are evident within the human time scale. Most of us are aware of other lakes that were in much better condition years ago than they are today.

C. The Condition of the WAW Lakes.

The Lakes of the Wawasee Area Watershed presently have among them the highest water quality of any lakes in Indiana. Most Indiana lakes have a Secchi depth reading of from 2 to 6 feet. The Lake Wawasee Secchi depth this summer has been as much as 15 feet. The introduction of zebra mussels may have helped to clear the lake up somewhat lately. Because the zebra mussel community and their effects are being studied by other researchers this project did not include a study of zebra mussels. However, their presence may be a problem to the aquatic community yet to be manifested.

In addition to having a deep Secchi reading, water column nutrient levels as measured in July 1995 continue to be relatively low, compared to other Indiana lakes, and sedimentation also continues to be low. Given the quality of these natural lakes, they should be considered a resource to be guarded jealously by their stewards.

The quality of the WAW is the reason the lakes' water quality continues to be so high. However, the water quality of area lakes could very easily take a turn for the worse, depending on how the watershed is managed. Although the condition of the subject lakes is good compared to other Indiana lakes, the decline of sensitive fish species such as cisco and lake sturgeon are indicators of long term reduction in the overall health of the lakes. An example of a degraded watershed would be a change in land use along the margins of the waterways from idle land to tilled up to channel edges.

D. The Condition of the Wawasee Area Watershed

A watershed is the lake drainage basin, that catchment area where, if a drop of water falls within the basin it has the opportunity to flow into the lake. An often used phrase in lake and watershed management today is "A Lake is a Reflection of its Watershed", this is very true.

The WAW is among the largest lake watersheds in Indiana at 24,000 acres. Presently it is one of the highest quality watersheds in the state, for three primary reasons:

1. the amount of water-purifying wetlands in the watershed;

2. the large number of highly erodible land (HEL) in some form of conservation tillage or idle land. In addition, there is some Conservation Reserve Program (CRP) acres in the watershed. HEL in CRP does not have the opportunity to contribute significant sediment loads due to stabilizing ground cover. And;

3. other conservation practices in place throughout the watershed.

Most of the CRP contracts are near expiration. CRP expiration could result in putting more acres of HEL into production. Conversion of idle land to agriculture production is the primary factor that could result in a future decrease in water quality of the WAW. The Wawasee Area Conservancy Foundation (WACF) should work with the local Soil and Water Conservation Districts (SWCD) to renew CRP contracts and to assist in recruiting more acres into the CRP program, as well as installing other treatments.

The watershed is unique in its high quality habitat and ability to support a highly diverse natural community (see endangered species section) including a very high concentration of rare species. These plants and animals can be considered "canaries in the coal mine". The ability of the watershed to support these species has diminished over time. This trend may be an indication that the watershed is losing some of its pollution absorbing and buffering capacity.

E. Watershed Nutrient and Sediment Loading

To determine a nutrient and sediment loading budget for Lake Wawasee and to determine which loading sources are most important, loading estimates were made based on average concentrations and flows from each source. Measurements of nutrients in local runoff and direct precipitation were not made during this study. Estimates of loadings from these sources depend on average values found in studies of other lakes. The nutrient parameters listed in the table below are phosphorus (P) and nitrogen (N). The Total Suspended Solids (Solids) is basically the sediment load of the tributaries.

When the available data were tabulated, the following results were obtained:

Table E.S. 1
Annual Nutrients and Suspended Solids Loading From Tributaries*

	Total P[1] kg/yr	Total N[2] kg/yr	Solids[3] kg/yr
Enchanted Hills Channel	350	22,400	36,000
Norris Branch	(30)	(1,300)	(1,000)
Launer Ditch	(130)	(14,000)	(11,300)
South Dillon Crk.	(180)	(16,000)	(18,400)
Turkey Creek	810	39,200	46,700
South Shore Ditch	20	1,300	11,300
Papakeechie Watershed	215	3,600	4,000
Bonar Lake Watershed	75	500	1,000
Local Runoff	400	5,000	8,000
Direct Precipitation	155	4,000	1,000
TOTAL	2025 **	76,000	108,000

[1] Total P = Total phosphorus loading to Lake Wawasee in kilograms per year.
[2] Total N = Total nitrogen loading to Lake Wawasee in kilograms per year.
[3] Total Solids = Total suspended solids (including sediment) in kilograms per year.
* Late spring and early summer high flow and base flow sampling events.
** This is a maximum estimate. Actual loadings are lower because many of the values used to calculate loadings were set at the analytical detection limit rather than the actual value below the detection limit. For determining acceptable loading rates (see page VII-11 for an explanation), this calculated value was multiplied by 0.75 (the factor below the detection limit used as an acceptable standard by IDEM).

Values in parentheses are for Dillon Creek tributaries as they enter the Enchanted Hills area.

During this study, phosphorus (P) and total suspended solids (TSS) were relatively low in concentration. However, nitrate loadings were unusually high in the Enchanted Hills subwatershed. Further study should be done to identify the source of elevated nitrates.

The tributary loadings of phosphorus are well below levels considered "permissible" by EPA standards (using the Vollenweider Model). A 1973 EPA study indicated that phosphorus was the limiting nutrient in Lake Wawasee water.

There is a considerable amount of highly erodible soils throughout the watershed, however, based on visual inspection, most appears to be relatively stable due to well managed ground cover. Most of the tilled highly erodible acres in the WAW are presently in a conservation tillage practice. A small portion of the HEL land in the WAW is in the Conservation Reserve Program (CRP). A large percent of the highly erodible land in a conservation tillage practice also have other erosion control features installed such as grassed waterways and filter strips. Some even have water and sediment control basins (WASCOBS) installed.

From aerial observations, the most obvious problem watershed wide is transport of sediment from construction sites. Best management practices should be installed for commercial, residential, utility, or any other kind of construction involving earth moving. An enforceable erosion control ordinance should be passed by the county. The Kosciusko County Lakes Council would be the appropriate body to lobby the county commissioners for such an ordinance.

F. In Lake Water Quality

1. Eutrophication Index Sampling Results

The in-lake water quality of the following lakes were sampled after they reached summer stratification:

- Lake Wawasee (two separate basins, two separate sampling occasions)*
- Syracuse Lake

- Bonar Lake

  * The two basins of Wawasee were each sampled on a Thursday (calm conditions) and on a heavy boating, Sunday July 3rd. The objective of this comparison was to determine if there is a measurable effect between high use periods and calm periods. From the methods used in this study, no measurable effect was detected.

The Indiana Department of Environmental Management (IDEM) uses a unique monitoring technique to determine the "trophic status" of lakes in Indiana. This technique, which has been rigorously tested and proven to produce very reliable results, uses 11 different measurements to produce an index value for any given lake. This value ranges between 0 and 75, with lower numbers indicating clear, "high quality" lakes and higher numbers indicating "problem" lakes with nuisance algae problems.

Commonwealth Biomonitoring staff calculated the IDEM lake eutrophication index (EI) for Lakes Wawasee, Syracuse, and Bonar during the summer of 1995. The following results were obtained:

Table E.S. 2
Eutrophication Index (E.I.) Values For Lakes Wawasee, Syracuse, and Bonar

Lake Name / Location	E. I. Values	Trophic Class
Wawasee - South Basin	10	I
Wawasee - North Basin	12	I
Syracuse Lake	10	I
Bonar Lake*	6	I

* Access to Bonar was granted by a homeowner.

2. Historical and 1995 Secchi Depth Comparisons

One of the most commonly used methods of measuring water quality is "Secchi Disk Depth." The Secchi disk depth reading is the depth at which a black and white disk lowered into the water column can no longer be seen at the surface. Measurements of Secchi disk depth have been made in Lake Wawasee fairly regularly by various government and academic researchers and by volunteers since 1974. A comparison of these measurements over time can help determine whether Lake Wawasee is becoming clearer or more turbid. Table E.S. 3 is a compilation of available Secchi disk depth data.

Table E.S. 3
Secchi Depth Trends

	1973-1989	1989-1993	1994-1995
Average Secchi Depth (Feet)	9.3	10.4	8.2
Standard Deviation	1.25	0.96	1.92
Number of Samples	>12	25	15

By applying a statistical test to these results, we observe that the average Secchi Disk Depth during the 1989-93 period was significantly greater (5%) than the value for the previous 1973-89 period. This finding indicates that water clarity improved somewhat during 1989-93. The greatest improvement occurred during the 1990-92 period, when average Secchi Depth was as high as 11.5 feet.

During the most recent two-year period, average lake clarity has decreased once again. The Secchi Disk Depths for 1994-95 were statistically less than they were for 1989-1993 but were not significantly different (5%) from those observed during the earlier 1973-89 monitoring period. These results suggest that the clarity of Lake Wawasee has not changed very much during 20 years, except for a brief period in the early 1990's.

3. <u>Kosciusko County Health Department 1995 Sampling Results</u>

Results from in-lake sampling studies performed by the Kosciusko County Health Department (as well as Commonwealth Biomonitoring limnological profiles) and the watershed sampling results consistently indicate high water quality prevails in the lower WAW lakes. However, the Enchanted Hills Subwatershed exhibited high nitrate concentrations, and the outlet to the Enchanted Hills channels consistently were murky or turbid.

Based on the sampling results bacteria is generally not a problem in the lake, with concentrations well below Environmental Protection Agency (EPA) standards for full body contact (235 cells/100 ml). The area near the outlet of Turkey Creek had the highest concentrations of bacteria in the water column and this is consistent with sampling done in previous years. Consistent with other Indiana water bodies, Atrazine (agricultural herbicide) was detected in measurable concentrations above maximum contaminant levels for potable water. Concentrations of Atrazine are not considered unsafe for recreation. Atrazine application in the watershed should be done with care to avoid increasing the concentrations in area waters. In-lake phosphorus concentrations were consistently low wherever tested.

The source of the high nitrate concentrations in the Enchanted Hills subwatershed and the elevated levels of bacteria near the mouth of Turkey Creek should be further investigated. Also more research needs to be done on the fate of on-board wastewater from boats moored at the marinas around Lake Wawasee. Commonwealth Biomonitoring staff are available to assist in these investigations.

Based on the in-lake water quality sampling performed in 1995, in-lake water quality of lower WAW lakes is holding steady. Testing done on Lake Wawasee and the WAW in 1995 may be the most comprehensive set of testing ever done for an Indiana Department of Natural Resources, Lake and River Enhancement (IDNR, LARE) project on one watershed. All results point to the relative high quality of the water in the WAW waterways.

4. Flushing Rate

The flushing rate of Lake Wawasee is 3.5 years as calculated by Purdue University researchers. This is a relatively long flushing rate which results in the prolonging of the residence time of pollutants in the water. Extension of the residence time of pollutants is not good for water quality. Once a lake with a slow flushing rate becomes polluted, it takes much longer for a reversal or an improvement of water quality to become apparent from lake enhancement treatments. In addition to a long flushing rate, Lake Wawasee is relatively deep with a relatively large volume. Thereby, the lake can absorb a lot of pollution before its effects are apparent. There is a delayed response between introduction of pollutants and degradation of water quality.

G. Special Problems and Considerations

1. Boating Impacts

The lake margin wetlands function as natural purification systems for water entering the lakes. They also function as habitats for diverse species of wildlife. The wetland areas, such as Conklin Bay, Johnson Bay, and Mud Lake, are vital to the health of a self-sustaining fishery of Lakes Syracuse and Wawasee. Based on the field observations by Commonwealth Biomonitoring aquatic biologists, these areas presently function as rich fish nursery areas. These wetlands are especially rich in juvenile game fish species.

Over the course of this project, Commonwealth Biomonitoring staff have seen these wetland hummocks bouncing violently from wave energy. Because there are no 200 foot marker buoys in place in Johnson Bay, Conklin Bay or the Southeast corner of Syracuse Lake, people ski up to the edge of these wetlands.

After observing the value of the lake margin wetland areas to the overall health of the lakes system, idle zones have been proposed in the shallower, more sensitive areas of Lakes Wawasee and Syracuse to protect the wetland resources and for public safety considerations. These areas include the southeast corner of Syracuse Lake, Mud Lake, Conklin Bay, and Johnson Bay. Portions of these areas, especially the southeast corner of Syracuse Lake, also include shallow water boating hazards that warrant reduced boat speeds.

2. Seawalls

Water waves can be either partially or totally deflected or reflected back into a lake from natural or manmade barriers. Reflection of waves implies a reflection of wave energy from the seawall back out into the lake without energy dissipation. A natural, gradually sloping shoreline or beach tends to dissipate energy rather than reflecting it back out into the lake.

Seawalls all around the perimeter of Lakes Syracuse and Wawasee are positioned at different angles. These seawalls are simply reflecting waves back into the lake from all angles. This reflection is why Lake Wawasee is such a rough lake with a standing chop that continues to swell long after boat traffic has passed or subsided. Water, being a relatively dense medium, is an excellent conductor of sound and vibration and where wave energy is not dissipated it continues to bounce off of seawalls around the lake. Therefore wave energy generated by boat traffic and wind is sustained in the lake system for relatively long periods of time.

This excessive turbulence could be a contributing factor in the disappearance of the soft stemmed water bulrushes. Further investigation is recommended to determine if wave energy is a major factor in water bulrush community survival rates. Commonwealth Biomonitoring scientists are available to perform this study.

A seawall design detail to diminish wave energy is included as Figure 10 on page X-6. Several seawall designs are proven at dissipating wave energy. The example shown in Figure 10 is a convex design which curls a wave back onto itself for energy dissipation. The reason this design detail was presented was because it is very similar in appearance to existing seawalls around the lakes and would blend in well aesthetically for new construction or refurbishment of existing seawalls.

3. Residential and Commercial Lawn Care

Local residential and commercial lawn care has the potential to affect water quality through pesticides and fertilizers applied to area lawns. There is no specific information available on lawn care practices in the Lake Wawasee area.

It is important to maintain a relatively dense vegetative ground cover on soil to reduce the rainfall impact and reduce the erosive potential of managed lawns. Whenever possible, lawns surrounding lakes should be fertilized sparingly. Potentially harmful nutrient loading can be drastically reduced if fertilizers derived from local sources (e.g. composted materials originating within the watershed itself) are used for lawn fertilization. On lawns that need nutrient enhancement, the grass clippings from lawn mowing should be left on the lawn for recycling of the nutrients that are in the grass clippings into biomass of new grass leaves, to reduce the net introduction of nutrients into the watershed from outside sources.

4. <u>Residential and Commercial Water Withdrawals</u>

A caveat of water withdrawal for residential or commercial lawn use has to do with return flows. Where flows from boat or car washing or lawn chemical application is allowed to return to a lake the water quality of the lake could be negatively impacted. This type of activity should be discouraged where pollutants may enter the water via overland flow or by entering a downspout, storm drain, or drain tile and flow into a lake.

According to the Indiana Department of Natural Resources (IDNR) Division of Water, there are two registered (permitted) surface water withdrawal facilities in Lake Wawasee. IDNR records for 1991-93 show that the Wawasee Golf and Country Club uses approximately 170,000 to 290,000 gallons of lake water per year for irrigation. The South Shore Golf Course uses an additional 24 to 40 million gallons per year for irrigation. Therefore, from 24,170,000 to 40,290,000 gallons per year are withdrawn from Lake Wawasee for commercial lawn irrigation from these two uses. There is no estimate of the quantity or quality of return flows re-entering Lake Wawasee from this irrigation activity. The total volume of water permitted for irrigation withdrawal is a very small proportion of the total Lake water. However, with the long flushing rate (3.5 years) the withdrawal of water for irrigation could potentially lower the lake levels and prolong the residence time of pollutants in the lake water column.

5. <u>Effects of Waterfowl on Water Quality</u>

There is a possibility in some lake systems that an overabundance of waterfowl may contribute to an unacceptable level of nutrient loading from untreated "droppings". A rough calculation was made of potential nutrient loading to Lake Wawasee using an established method.

In a worst case situation waterfowl in Lake Wawasee could contribute up to 2% of all nitrogen loading and 14% of all phosphorus loading in the lake. This amount of loading is less than that from agricultural runoff, precipitation, and septic tanks. Removing all nutrient loading from waterfowl droppings would have no significant effect on the lake's "Trophic Index" of nutrient enrichment.

Since large flocks of waterfowl resting on the WAW lakes is seasonal, waterfowl concentrations in the Wawasee area are not a significant potential contributor to lake enrichment. However, feeding of waterfowl to attract a larger resident flock should be discouraged. The negative aspects of waterfowl manure nutrient loading is likely offset by the positive aesthetic value of waterfowl and their foraging on zebra mussels.

6. Management of Wetlands Around the Perimeter of the Lakes

Most of the former wetlands around the perimeter of the lakes have been filled in for residential and commercial development. This makes the remaining wetlands even more valuable.

The wetlands function as natural purification systems for water entering the lakes. They also function as habitats for diverse species of wildlife. The wetland areas, such as Conklin Bay, Johnson Bay, and Mud Lake, are vital to the health of a self-sustaining fishery. These areas presently function as very rich fish nursery areas. From the observations of researchers on this and previous projects, they are very rich in juvenile game fish numbers and species diversity.

These areas should be preserved around the lake for a variety of reasons, including their NPS pollution buffering, habitat value, wave energy buffering, aesthetic and intrinsic values.

No-wake zones should be established in the more sensitive wetland areas of the lakes to protect the wetland ecosystems from boating impacts.

H. Watershed Problem Areas

Through analysis of over 100 water quality samples; study of aerial photography; watershed reconnaissance via automobile, foot travel, canoe travel, a flyover in a small airplane; and from extensive mapping of land use in the watershed, Commonwealth Biomonitoring staff was able to identify several potential and existing non-point source water pollution problem areas throughout the WAW. These have been termed "Hotspots".

In Section XIII, Table 27 presents what are believed to be the most cost-effective non-point source (NPS) pollution control alternatives feasible for application in the WAW. A Watershed Management Plan, in Section XV, take the economic data from Table 27 and applies the most cost-effective practices from that cost table to the NPS problems listed in Section XI for development of a plan to effectively treat the watershed.

Based on the results of watershed water quality sampling and total annual loadings of nutrients and suspended solids (nonpoint source pollutants) to Lake Wawasee from each respective subwatershed, these subwatersheds have been prioritized from highest to lowest priority.

1. Turkey Creek Subwatershed
2. Enchanted Hills Subwatershed
3. South Shore Subwatershed
4. Immediate Lakeshore Land Uses
5. On Lake Uses
6. Bonar Lake Subwatershed
7. Papakeechie Lake Subwatershed

Within each subwatershed table there is a listing of the hotspots located in that subwatershed, also presented in order of priority from highest to lowest. The priority ranking is based on their relative severity and position in the landscape. These factors determine the ability of pollutants to reach waterways from each of these sources.

The following tables are presented in order of subwatershed priority and within each table the individual hotspots are prioritized within each subwatershed.

Table E.S. 4
Turkey Creek Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
29	Southeast Quarter of Section 30, Township 34 North, Range 8 East, Noble County.	Cattle on steep HEL adjacent to and in Turkey Creek.
9	Section 5. Township 33 North, Range 8 East	HEL in field near ditch going to Gordy Lake, possible buffer strips.
7	Section 30, Township 34 North, Range 8 East	Field and pasture erosion in HEL; near Turkey Creek has buffer.
8	Section 30, Township 34 North, Range 8 East	Field erosion near Turkey Creek, not all in HEL, but has forested buffer.
12	Section 32, Township 34 North, Range 8 East	Field erosion in HEL.
18	Section 8, Township 33 North, Range 8 East	Field erosion in HEL.
10	Section 5, Township 33 North, Range 8 East	Field erosion near ditch between Gordy and Hindman, some forested buffer, possible grassed waterway.
17	Section 8, Township 33 North, Range 8 East	Field erosion in HEL near ditch that goes to Hindman Lake
16	Section 7, Township 33 North, Range 8 East	Field erosion in HEL near ditch that goes to Hindman Lake, no existing buffer strips.
11	Section 32, Township 34 North, Range 8 East	Field erosion next to ditch going to Rider Lake, no buffer strips.
13	Section 32, Township 34 North, Range 8 East	Field erosion in HEL.
14	Section 28, Township 34 North, Range 8 East	Field erosion near ditch that goes to Rider Lake, possible grassed waterways.

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
27	Northwest Quarter of Section 34, Township 34 North, Range 8 East	Field erosion near ditch to Knapp Lake.
21	Section 3, Township 33 North, Range 8 East	Field erosion in HEL area, near ditch that goes to Harper, buffer strips.
20	Section 3, Township 33 North, Range 8 East	Field erosion in HEL.
19	Section 4, Township 33 North, Range 8 East	Field erosion in HEL area.
28	Northeast Quarter of Section 10, Southeast Quarter of Section 3, Township 33 North, Range 8 East	Erosion on HEL adjacent to ditch.
22	Section 3, Township 33 North, Range 8 East	Field erosion in HEL area, near Pipe Branch Ditch.
23	Section 2, Township 33 North, Range 8 East	Field erosion in HEL area, near Piper Branch Ditch
6	Section 30, Township 34 North, Range 8 East	Field and pasture erosion in HEL.
25	Section 2, Township 33 North, Range 8 East	Field erosion in HEL.
24	Section 2, Township 33 North, Range 8 East	Field erosion in HEL.
26	Section 11, Township 33 North, Range 8 East	Field erosion in HEL.
15	Section 27, Township 34 North, Range 8 East	Field erosion in HEL, more grassed waterways needed
32	Mouth of Turkey Creek in Lake Wawasee	High bacteria counts, needs further study.

Table E.S. 5
Enchanted Hills Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
1	Sections 13, 24, & 19, Township 34 North, Range 7 East. General area of Launer Ditch & Dillon Creek	Field rill, gully erosion; channel grading

4	Section 19, Township 34 North, Range 8 East	Field erosion near ditch.
5	Section 20, Township 34 North, Range 8 East	Field rill, gully erosion
General	Enchanted Hills Subdivision	Erosion from bare soil and construction sites. Stabilize channel banks. Maintain healthy ground cover without high P content fertilizer. Harvest macrophytes rather than herbicide treat for nutrient removal.

Table E.S. 6
Southside Country Club Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
30	Northeast Quarter of Section 20, NPW Subdivision, east of South Shore Country Club	Construction site run-off.
General	Sections 21 & 22. Farm land east of South Shore Country Club	Conservation tillage needed on fields.

Table E.S. 7
Other Lakeside Localized Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
32	Section 24, Township 34 North, Range 7 East. Mouth of Turkey Creek	High bacteria counts, possibly from marina or mobile home park. Needs further study.
2	Section 22, Township 34 North, Range 7 East. East of high school	Field erosion in conventional tilled area in HEL.
31	Section 8, Conklin Bay North Point "The Slip" area	Bare construction site contained by seawall.
General	Perimeter of lakes	Construction and lawn care activities must stabilize soils with minimum of phosphorus fertilizer inputs.

Table E.S. 8
On-Lake Use Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	All over lakes	-- Wake in wetlands areas - resuspension -- High speed operation in shallow (<5') areas -- Lack of head pumping facilities -- Lake use etiquette (pollution prevention) -- Advertise public restroom facilities (discourage "going in lakes")

Table E.S. 9
Bonar Lake Subwatershed Potential Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	Section 4, Township 34 North, Range 7 East. Lake margins	May need sewers. Bacteria sampling needed.
General	North of lake	Crop land on HEL.

Table E.S. 10
Papakeechie Lake Subwatershed Potential Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	Section 25, Township 34 North, Range 7 East. Papakeechie Road	Auto salvage yard. Potential leaching from site.

I. County Land Use Planning

Presently both Kosciusko County and Noble County have comprehensive land use plans for their counties but the plans do not include special provisions or ordinances concerning protection of aquatic resources. Both county governments should develop ordinances and specific land use plans that provide for the protection of water resources from cultural pollution.

The WACF should work through a larger lakes council body, such as the Kosciusko County Lakes Council or the Indiana Lake Management Society, to encourage county officials to develop and adopt enforceable land use plans that protect water bodies from degradation due to land use activity.

J. Evaluation of the Operation of the Dams of Lakes Papakeechie and Syracuse

Discussion of Positive and Negative Aspects of Seasonal Dam Operations

Winter drawdown is generally a good lake management practice for nuisance macrophyte control and to oxidize sediments to create a tighter bond between the sediment associated nutrient molecules and soil particles.

Given the nature of the natural lakes of the WAW and the established legal lake levels which must be maintained, seasonal dam operation is not a feasible alternative for the operators of the Syracuse Lake Dam. Dam operators are flooded with complaint calls in the spring of the year with only minor (.5') fluctuations of the water level. If the operators were to try to manipulate water levels for lake management purposes, the plan would have to be well publicized and supported by property owners.

1. Discussion of General Conditions of Dam Structures and Apparatus

The structure of the Syracuse Lake Dam at Crosson Park is in excellent condition. The existing dam was constructed in 1963 with funds donated by Eli Lilly (along with an operations and maintenance fund established at the same time). The structure is very well maintained and Indiana Department of Natural Resources (IDNR) dam inspection reports indicate that there is presently no problem with the dam, nor has there been, since construction of the existing dam.

a. Syracuse Lake Dam Operations

The Town of Syracuse dam operation staff have tried various strategies to maintain the lake level as stable as possible, including reactionary versus anticipatory strategies to maintain a stable lake level. The anticipatory strategy was tried but has been abandoned for the reactionary management strategy.

The water must be released from the Syracuse Dam at a controlled rate to prevent causing damage (erosion) to the channel downstream of the Lake and to protect property below the Lake. A minimum amount of flow must be maintained by the dam operator to maintain a stream ecosystem in Turkey Creek below the Syracuse Dam.

The urbanization of portions of the WAW, which has included replacement of wetland and natural pervious soils with impervious rooftops and pavement, has altered the rate of water flow to the lakes and has resulted in the operation of the dam requiring more operator attention to maintain the legal level. Operators of the dam must try to compensate for ever decreasing peak runoff "times of concentration" and the increasing volumes of peak runoff to the lakes system.

b. Papakeechie Dam

The Papakeechie Dam is operated by the Papakeechie Property Owners Association.

The Papakeechie Dam is in satisfactory condition. While the east end of the earthen dam appears to be lower, to function as an emergency spillway, there is no evidence of there ever being an overtopping of the earthen dam. The outlet structure of the Papakeechie Dam appears to also be in reasonably good operating condition. It consists of a simple stop plank structure with an operable sluice gate as a backup control. From the field inspection, all the working parts appear to be functional.

The sluice gate at the dam is operable and this is how water level is manipulated at the dam. During and after storm events the gate opening is manipulated to prevent the lake from overtopping the emergency spillway. Sluice gate operation is mainly confined to the heavy rains of spring and winter.

The dam structure is in good condition according to IDNR inspection reports. The PPOA is presently saving money for an improvement to the emergency spillway.

K. Modeled In Lake Responses To NPS Pollution Controls

By using the lake management industry standard lake response computer model EUTROMOD, different watershed management strategies were modeled to provide an estimate of the in-lake water quality response to the management strategies.

Given the existing relatively good overall condition of the WAW, the quality of Lake Wawasee water (low concentrations of phosphorus), and the volume of the lake, it is difficult to achieve a substantial reduction in phosphorus concentrations from the water column, such that there would be a measurable result from the nutrient reduction. The model predicted the largest increase in water quality improvement would come from eliminating individual septic systems in the watershed.

L. Watershed Treatment Strategy

Overall, the treatments needed to stabilize identified watershed problem areas are relatively low cost agricultural conservation measures. For agricultural portions of the WAW, most measures include development of grassed waterways; filter strips; implementation of integrated nutrient management; conservation tillage; and critical area shaping, seeding and mulching. The estimated cost to implement these recommended measures is less than $400,000. More detailed on-site planning performed by a local resource agency should be performed to identify more needs and to develop alternatives that will be most workable for individual producers.

For construction site and suburban and residential areas of the WAW, stabilization of bare soil through properly maintained vegetation and installation of erosion control best management practices (BMPs) should be implemented.

The Knapp Lake, Little Bause Lake, and Harper Lake areas need to be sewered based on Noble County Health Department reports. Further investigation needs to be done to verify a problem with septic leachate and bacterial contamination into one or more of the lakes. Further investigations should include performing lake eutrophication index sampling on the lakes and bacteria sampling around the lakes. As elaborated on later in this report, the WAW has been unique in its capacity to filter water pollution. However, the decline of cisco populations and other species in the watershed lakes indicates that the capacity to absorb, or treat, pollutants in the WAW ecosystem may be diminishing. The health of the entire WAW ecosystem is dependent on the maintained health of all of the interconnected sub-ecosystems.

A small portion of highly erodible acres is presently in CRP, the CRP contracts will expire on approximately 90% of the CRP ground in the next 1 to 2 years. It is imperative that conservation measures are installed on this HEL prior to the land being put back into crop production. The Wawasee Area Conservancy Foundation (WACF) can work with the local District Conservationists to recruit landowners to put acreage in the CRP program or to develop cost-share programs for landowners to implement best management practices on their land.

Section II

Introduction and Background

II. INTRODUCTION AND BACKGROUND

A. General Introduction

Given the magnitude of the watershed and the myriad issues that could potentially impact the water quality of the Wawasee Area Watershed (WAW), it was imperative for the scope of this study to not only meet the technical requirements of the Indiana Department of Natural Resources (IDNR) Division of Soil Conservation, but also for the scope of the project be generated by the Wawasee Area Conservancy Foundation with the guidance of IDNR and the professional scientists at Commonwealth Biomonitoring.

The Wawasee Area Watershed Diagnostic/Feasibility Study included identifying and investigating specific and unique conditions within the WAW, including:

- a thorough analytical evaluation of water quality within Lake Wawasee, its channels and tributaries, Syracuse Lake, and Bonar Lake;
- identification of the potential sources of water quality impairment and quantification of the magnitude of the pollution problem generated by identified sources within the watershed, and lake margins;
- an evaluation of viable alternatives to cost-effectively control pollution from identified sources, and to maintain the condition of areas presently not contributing significant water quality problems to the lakes or their tributaries, and;
- development of a watershed management plan to serve as both a long term preventive maintenance guide and as a manual for proceeding with implementation of the most feasible non-point source pollution control strategies.

1. Summary of Perceived Problems

a. Watershed Sources of Water Quality

A popular phrase today is that a lake is a reflection of its watershed. The soil types, environmental conditions, land use and other human activities within a watershed have a major impact on the water quality of any given lake. The lakes of the Wawasee Area Watershed (WAW) are no exception. As will be elaborated on later in this report, the WAW has been unique in its capacity to filter water pollution. However, the decline of cisco populations and other species in the watershed lakes indicates that the capacity to absorb, or treat, pollutants in the WAW ecosystem may be diminishing.

The investigation of watershed conditions was conducted through sampling, visual field investigation and aerial reconnaissance, as well as examining existing maps, aerial photographs and previous reports.

b. In-Lake Sources of Water Pollution

Given the intensity of recreational use on Lake Wawasee and the number of dwellings around the lake, it is generally perceived that there are some water quality impacts resulting from the intense human use. The direct impact of human activity on water quality is one of the most difficult aspects of lake water quality to quantify. However, despite the intensive recreational use, the water quality of the lake has been relatively well maintained, evidently by primarily natural forces. Unlike many other lakes in Indiana, there is no prominent evidence of serious water quality impairment within the area lakes that were sampled for water quality.

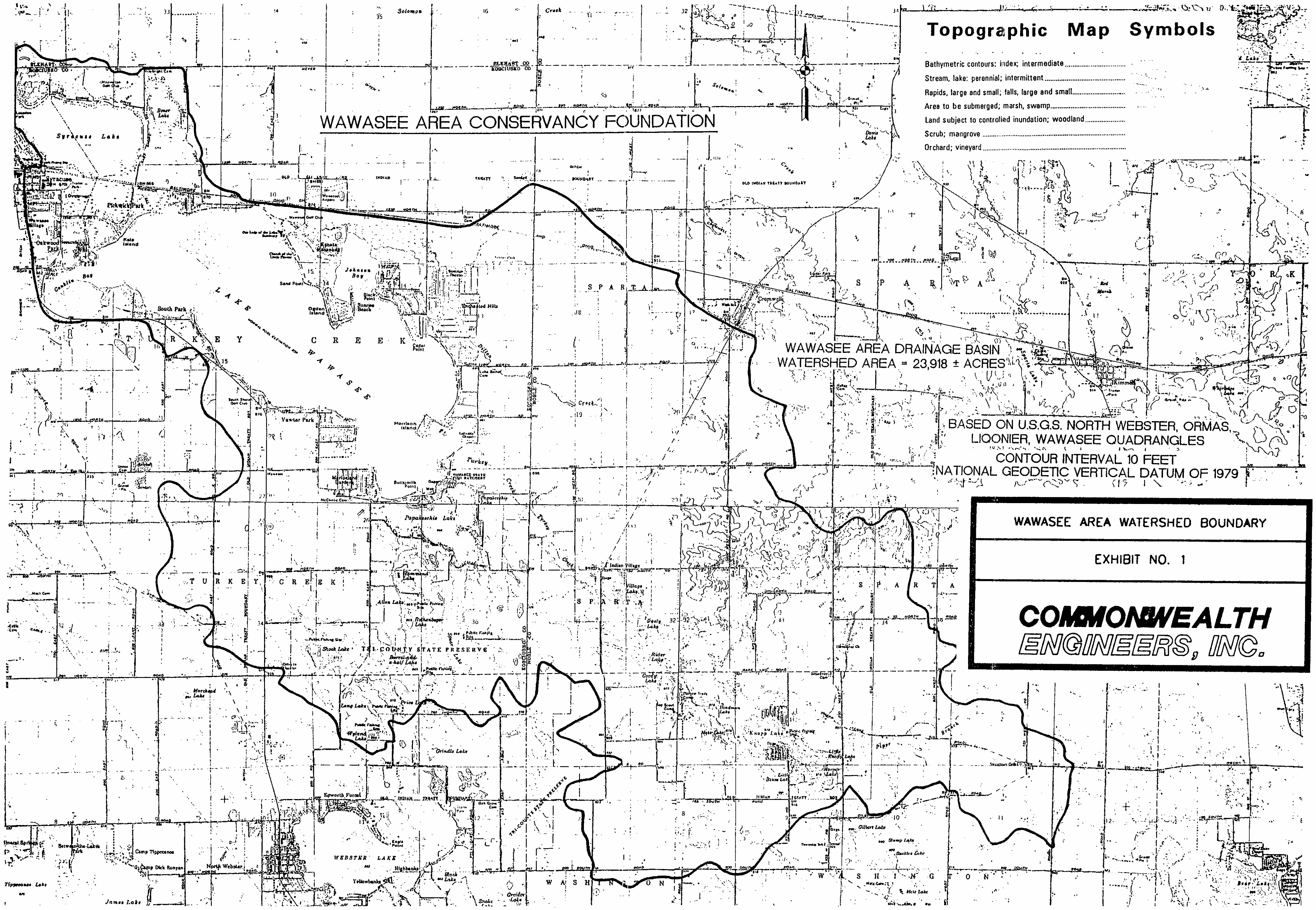
c. Other Potential Problems to Address

Section X will deal with several issues that pertain to on-lake use or lake margin land use. These include:

- Environmental Effects of Motorized Watercraft in Shallow Water
- Environmental Effects of Sea Walls
  - → Inventory of Sea Wall Types and Map
  - → Recommended Types of Sea Wall Construction
- Residential Lawn Care
- Effects of Waterfowl on Water Quality
- Changes in Aquatic Vegetation
- Macrophyte (aquatic vegetation) Management in Channels
- Management of Wetlands Around the Perimeter of the Lakes

B. Background Considerations

The Wawasee Area Watershed (WAW) was inhabited by Native Americans and used for hunting grounds until 1832 when a treaty was signed and the Indians were removed to reservations. The area was then settled primarily by western European descendant inhabitants. Soon thereafter the counties, cities and towns of the watershed were established. These communities were centered around grist mills at first. Soon afterward other types of commerce followed. Today the watershed is primarily in agricultural production. Exhibit 1 delineates the watershed on the United States Geological Survey (U.S.G.S.) maps.


WAWASEE AREA CONSERVANCY FOUNDATION
Topographic Map Symbols
Bathymetric contours: index; intermediate
Stream, lake: perennial; intermittent
Rapids, large and small; falls, large and small
Area to be submerged; marsh, swamp
Land subject to controlled inundation; woodland
Scrub; mangrove
Orchard; vineyard
WAWASEE AREA DRAINAGE BASIN
WATERSHED AREA = 23,918 ± ACRES
BASED ON U.S.G.S. NORTH WEBSTER, ORMAS, LIGONIER, WAWASEE QUADRANGLES
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1979
WAWASEE AREA WATERSHED BOUNDARY
EXHIBIT NO. 1
COMMONWEALTH ENGINEERS, INC.
LAKE WAWASEE
Syracuse Lake
WEBSTER LAKE
TURKEY CREEK
SPARTA
YORK
WASHINGTON
TRI-COUNTY STATE PRESERVE
Cromwell
Kimmell
Syracuse
South Park
Vawter Park
North Webster

1. Geography and Topography

In geologic terms, the WAW is located in the Stueben Morainal Lake Area of the Northern Moraine and Lake Region physiographic area. The southern half of the watershed is rolling, highly dissected by glacial moraines (mounds of unconsolidated deposits formed by glacial activity) and poorly drained alluvial (formed by rivers or streams) bottomland, with numerous depressional wetland areas. Such a landscape is generally referred to as sag and swell topography. The northern half of the watershed is somewhat flatter, with the Noble County portion of the northern half primarily in agriculture production and the Kosciusko County portion of the northern half being primarily in urban and residential land uses on upland areas.

The 3,486 acre Tri-County Fish and Wildlife Area (TCF&WA) in the southwestern portion of the WAW is similar in topography to the southeastern portion of the WAW but the land use is significantly different. The TCF&WA is composed of flat to rolling upland fields with gradual to steep slopes with stands of mixed hardwood trees. Most of the upland sites drain into depressional wetland areas and nine natural lakes as deep as 59 feet. In addition to the natural lakes, there are two manmade lakes within the TCF&WA.

2. Groundwater and Soils

a. Groundwater

The primary source of drinking water in the WAW is from groundwater supplies. Thick deposits of unconsolidated glacial till, composed primarily of sand and gravel outwash deposits, are approximately 300 to 325 feet thick over the top of a Devonian-Mississippian carbonate (limestone) bedrock. The carbonaceous bedrock is itself relatively permeable for bedrock; however, given the high yield of water from unconsolidated aquifers positioned on top of the bedrock, the permeability of the bedrock has not actually been measured. This outwash material is relatively pervious and allows relatively free flow of groundwater through the unconsolidated deposits.

Because of the availability of groundwater for use as a water supply, it is doubtful that there will be any demand for withdrawing lake water for any use other than residential irrigation and washing or for commercial irrigation of golf courses. In fact, further withdrawals from the lakes should be discouraged.

The direction of groundwater flow in the WAW generally follows the same pattern as surface water flow, from a southeast to northwest direction through the watershed.

According to an IDNR Division of Water, Piezometric Surface Map for Unconsolidated Deposits, there is approximately 30 - 40 feet of potentiometric (potential energy gradient) groundwater head difference from the southeast to the northwest through the WAW. East of Knapp Lake in Noble County is the highest groundwater surface of the WAW with a groundwater surface elevation being between 875 and 900 feet above sea level. Near the outlet of Syracuse Lake, the groundwater surface elevation is slightly less than 850 feet above mean sea level.

The groundwater surfaces above roughly correlate to the bedrock surface elevations as well. At the upper end of the WAW the bedrock elevation is roughly 600 feet above mean sea level. At the downstream end of the WAW the bedrock surface elevation is approximately 560 feet above mean sea level.

There presently is a well testing program being conducted by the Kosciusko County Soil and Water Conservation District (SWCD) in cooperation with the Arrowhead Resource Conservation and Development Council (RC&D).. This project is testing for bacteria, nitrates, and pesticides (Lasso and Atrazine) in private well water. Preliminary results are in for the well testing program and of the private well water tested in Kosciusko County the water quality is in acceptable condition for drinking water supply wells.

Recently, similar studies in Elkhart County have shown that many Elkhart County private wells contain elevated levels of nitrates.

b. <u>Soils - Kosciusko County and Noble County</u>

The soils of the watershed consist primarily of sandy loams with substantial areas of heavier (more erodible) soils on the upland areas. The wetland areas have sandy to silty organic mucks which are not highly erodible. The waterways have soils which are primarily marls, sand, and mucks. Most of these soils are not conducive to being transported by storm events as the soil is generally permeable, allowing water to infiltrate and be absorbed by the soil. The numerous wetlands in the watershed also retard runoff and erosive effects of runoff. However, there are substantial areas of highly erodible soils (Miami-Riddles) and potentially highly erodible soils in the Turkey Creek subwatershed. More detail on the watershed soils is provided in Section VI.

3. Hydrology and Drainage Basins of the WAW

a. Precipitation and Climatology

Precipitation is the source of all fresh water either on the surface or in the subsurface of the earth. The amount, distribution and mode of occurrence of precipitation, as well as geology, combine to define a region's hydraulic regime. Average annual precipitation of the WAW is 35.5 inches per year. Approximately 60% of the annual precipitation (20 inches) falls during the growing season. The other approximately 40% of the precipitation falls during non-growing seasons when runoff is higher due to decreased evapotranspiration, decreased ground cover, and saturated or frozen ground. There are approximately 40 thunderstorms in an average year in the WAW. The average annual depth of snowfall is 26 inches. The prevailing wind is from the northwest.

The WAW experiences only a small amount of the lake effect (Lake Michigan) snow or precipitation compared to locations such as South Bend just to the northwest.

There is a U.S. Geological Survey gaging station located at the outlet of Syracuse Lake on Turkey Creek near Crosson Park. This gaging station has been recording flows from the WAW drainage system since 1943. There are approximately 38 total square miles of drainage area upstream of the gaging station. Because there is a control structure (operable dam) to control the flow measured by this gaging station, the gage only monitors lake outflows rather than regional hydrology.

The U.S.G.S. has monitored lake levels at Syracuse Lake continuously since 1943. During the past 50 years, the difference between maximum and minimum gauge heights at Syracuse Lake has been only 3.15 feet. The annual rise and fall of lake levels is normally less than 1 foot (Stewart et al., 1993).

The lakes of the WAW are very important for the purposes of groundwater recharge and discharge. Most of the WAW lakes evidently have a net discharge of groundwater (via springs) to the surface water. This discharge is part of the reason there is such good surface water quality in the Turkey Creek subwatershed of the WAW. The estimated rates of groundwater recharge or discharge to and from WAW lakes is not available, and have been considered insignificant by previous researchers. Therefore, groundwater flow was not included in the water budget.

b. Lakes Data and Legal Levels of the WAW Lakes

The U.S.G.S., in cooperation with the IDNR, have monitored the level of lakes across Indiana. A number of lakes have been monitored within the WAW, some in both Noble County and Kosciusko County . These lake levels were initially monitored to establish legal lake levels under IC 13-2-13. Now these stage monitoring stations are used for lake management purposes and for IDNR lake permit purposes. The IDEM has also performed several analyses of WAW lakes. Tables 1 and 2, on pages II-11 and II-12 respectively, present available physical and trophic data for lakes of the WAW. The drainage area for each lake represents the watershed area of the lake. Records have not been maintained on all parameters for each lake. The data presented in the tables was gathered prior to 1986. Two of the parameters, Trophic Class and Lake Management Group, listed in Table 1 need further definition.

The Trophic Class is a system developed by the Indiana Department of Environmental Management (IDEM) to classify lakes according to ten diagnostic parameters including physical, chemical, and biological measurements (see pages IX-1 and IX-2 for a list of parameters sampled) made during the summer thermal stratification in the deepest portion of the lake basin. The results of the measurements are assigned points based on the quantitative values measured for each parameter. After the point value for each parameter measure is totaled the result will total from 0 to 75 points. The higher the point total, the higher the level of eutrophy, or nutrient enrichment. Indiana Lakes are then classified into one of three broad classifications based on the total eutrophy points from measured parameters.

Class One lakes have the highest water quality, or lowest level of eutrophication, of the three lake classes. The total eutrophy points for Class One lakes are from 0 to 25 points. These lakes typically have clear water and rarely have macrophyte or algae problems considered a nuisance, except within manmade channels.

Class Two lakes have intermediate water quality, and an intermediate level of eutrophication. Total eutrophy points for Class Two lakes range from 26 to 50 points. Class Two lakes are usually productive waters frequently supporting extensive growth of macrophytes and/or algae. Occasionally, the macrophytes will require management to prevent lake use impairment. The majority of Indiana's natural lakes are in Class Two.

Class Three lakes have the lowest water quality, exhibiting advanced eutrophic conditions. the total eutrophy points for Class Three lakes range from 51 to 75 points. Lake use is commonly impaired. This class always has extensive concentrations of macrophytes and algae during the growing season. Blue-Green algae species are the dominant phytoplankton genus. Fish kills may even occur from oxygen depletion in summer or under ice. Class Three lakes are considered hyper-eutrophic.

Class Four lakes are considered remnant natural lakes or oxbows with small surface areas, shallowness, or in an advanced state of senescence. Class Four lakes typically have comparatively low nutrient profiles due to uptake by macrophytes. Many Class Four lakes are filled with macrophytes or sediment and are aging to the point of evolving into a wetland habitat.

The Lake Management Group (different from the Trophic Class), as listed in Table 1, refers to the 1986 IDEM recommended management plan strategy for Indiana Lakes. Indiana lakes were classified by identified problems causing advances in their trophic status. Then broad management strategies were developed to formulate a management plan for Indiana Lakes. Following is a list of management strategy categories:

Lake Management Groups	Lake Group Management Strategy
I	1. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Septic tank maintenance programs. 2. Land use practice and watershed management. a. Buffer strips for lake shore and tributary banks. b. Protection of watershed wetland areas. c. Erosion control. d. Zoning and development regulation.
IIA and IIB	1. Government or private protection. a. Acquisition of shoreline. b. Restricted shoreline development and use. c. Restricted recreational use. d. Maintenance of existing aesthetic qualities. 2. Educational programs for lake and area residents to increase awareness of the natural resource value of these lakes.

Lake Management Groups		Lake Group Management Strategy
IIA and IIB	3.	Maintenance of water quality. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Land use control in watershed. c. Protection of watershed wetland areas.
IIC	1.	Wastewater treatment. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Septic tank maintenance programs.
	2.	Land use practice and watershed management. a. Buffer strips for lake shore and tributary banks. b. Protection of watershed wetland areas. c. Erosion control. d. Zoning and development regulation.
	3.	Restoration a. Nutrient inactivation. b. Selective discharge. c. Macrophyte harvesting. d. Chemical controls (algacides).
III	1.	Wastewater treatment. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Septic tank maintenance programs.
	2.	Land use practice and watershed management. a. Buffer strips for lake shore and tributary banks. b. Protection of watershed wetland areas. c. Erosion control. d. Zoning and development regulation.
	3.	Restoration a. Macrophyte harvesting. b. Sediment consolidation by drawdown.
IV	1.	Restoration a. Aeration and/or circulation. b. Chemical controls (algacides). c. Macrophyte harvesting. d. Nutrient inactivation. e. Sediment consolidation by drawdown. f. Dredging. g. Lake bottom sealing.

Lake Management Groups	Lake Group Management Strategy
IV	h. Selective discharge. I. Dilution/flushing. j. Various combinations of above restoration techniques. 2. Wastewater treatment. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Septic tank maintenance programs. c. Diversion. d. Nutrient traps (constructed wetland areas) 3. Land use practice and watershed management. a. Buffer strips for lake shore and tributary banks. b. Protection of watershed wetland areas. c. Erosion control. d. Zoning and development regulation.
V	1. Government or private protection a. Acquisition of shoreline. b. Restricted shoreline development and use. c. Restricted recreational use. d. Maintenance of existing aesthetic qualities. 2. Educational programs for lake and area residents to increase awareness of the natural resource value of these lakes. 3. Maintenance of water quality. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Land use control in watershed. c. Protection of watershed wetland areas.
VI	1. Wastewater treatment. a. Wastewater treatment plant construction or upgrades to include phosphorus removal. b. Septic tank maintenance programs. c. Diversion. d. Nutrient traps (constructed wetland areas) 2. Land use practice and watershed management. a. Buffer strips for lake shore and tributary banks.

Lake Management Groups		Lake Group Management Strategy
VI		b. Protection of watershed wetland areas.
		c. Erosion control.
		d. Zoning and development regulation.
	3.	Restoration
		a. Nutrient inactivation.
		b. Selective discharge.
		c. Macrophyte harvesting.
		d. Chemical controls (algacides).
VII	1.	Wastewater treatment
		a. Wastewater treatment plant construction or upgrades to include phosphorus removal.
		b. Septic tank maintenance programs.
		c. Diversion.
		d. Nutrient traps (constructed wetland areas)
VII and VIIB	2.	Land use practice and watershed management.
		a. Buffer strips for lake shore and tributary banks.
		b. Protection of watershed wetland areas.
		c. Erosion control.
		d. Zoning and development regulation.
	3.	Restoration
		a. Macrophyte harvesting.
		b. Chemical controls (algacides).
		c. Sediment consolidation by drawdown.
		d. Dilution/flushing

Table 1
Physical and Trophic Data* and Indiana Lake Management Group for Noble County Lakes

Lake Name	Drainage Area (mi^2)	Surface Area (acres)	Established Level	E.I.**	Trophic Class	Management Group
Gordy Lake	9.40	31	876.68 ft.	43	II	VIIB
Knapp Lake	6.02	88	878.25 ft.	43	II	IIC
Duely Lake		21		42	IV	V
Harper Lake		11		60	III	VIIB
Hindman Lake		13		52	IV	V
Indian Village Lake		12		59	IV	V
Moss Lake		10		51	IV	V
Rider Lake		5		55	IV	V

* Taken from Indiana Lake Classification System and Management Plan, IDEM, 1986 (no dates provided for data)

** = Eutrophication Index (E.I.) value

Table 2
Physical and Trophic Data* and Indiana Lake Management Group for Kosciusko County Lakes

Lake Name	Drainage Area (mi^2)	Surface Area (acres)	Established Level	E.I.**	Trophic Class	Management Group
Barrel-and-a-Half		12		46	IV	V
Bonar Lake		40		43	II	VIIC
Bufflehead Pond		10				
Hammond		12				
Lake Wawasee	36.9	3,410	858.89	16	I	I
Papakeechie Lake	5.52	300				
Shock Lake		37		28	II	IIC
Spear Lake		40		36	II	VIA
Syracuse Lake	38.2	414	858.87	12	I	V

* Taken from Indiana Lake Classification System and Management Plan, IDEM, 1986 (no dates provided for data)

** = Eutrophication Index (E.I.) value

4. Natural Areas, Rare, Threatened, and Endangered Species-Map

Information on critical habitats; unique natural areas; and rare, endangered, and threatened species was obtained from the IDNR Division of Nature Preserves.

The Indiana Department of Natural Resources (IDNR) Division of Nature Preserves maintains a database of rare plants and animals throughout the state, as part of its Natural Heritage Trust program. A print-out of IDNR's database for the Turkey Creek watershed upstream from Syracuse Lake is attached in "Volume 1, Lake Wawasee Compilation of Previous Studies and Reports". A summary of information pertaining to aquatic species is shown below:

a. Species of Concern in the Immediate Lake Wawasee/Syracuse Lake Area

(1) Highest Level of Concern

State Endangered Species Present (in danger of extinction)

Blanding's turtle	Emydoidea blandingii
Oakes pondweed	Potamogeton oakesianus
Straight-leaf pondweed	Potamogeton strictifolius

(2) Secondary Level of Concern

State Threatened Species Present (likely to become endangered)

Spotted turtle	Clemmys guttata
Whorled water milfoil	Myriophyllum verticillatum
Redhead grass	Potamogeton richardsonii

(3) Third Level of Concern

Rare or "Watch List" Species (may become "threatened")

Mudpuppy	Necturus maculosus
Blacknose shiner	Notropis heterolepis
Water bulrush	Scirpus subterminalus

b. Additional Species of Concern in the Upper Turkey Creek Watershed (upstream of Syracuse Lake Dam)

(1) Highest Level of Concern

State Endangered Species Present (in danger of extinction)

Beck water marigold	Bidens beckii
Oakes pondweed	Potamogeton oakesianus
Fries' pondweed	Potamogeton friesii

(2) Secondary Level of Concern

State Threatened Species Present (likely to become endangered)

Eastern massasauga rattlesnake	Sistrurus catenatus
Horned bladderwort	Utricularia cornuta

(3) Third Level of Concern

Rare or "Watch List" Species (may become "threatened")

Cisco	Coregonus artedi

The following list of endangered, threatened, or rare species are known to exist primarily in "clear" water (their survival may depend on keeping suspended solids from silt and algae to a minimum):

Whorled water milfoil	Myriophyllum verticillatum
Redhead grass	Potamogeton richardsonii
Blacknose shiner	Notropis heterolepis

The following list of endangered, threatened, or rare species depend on areas of undisturbed meadow or undergrowth along lake margins:

Blanding's turtle	Emydoidea blandingii
Spotted turtle	Clemmys guttata
Eastern massasauga	Sistrurus catenatus

The following species require lakes with a combination of cool water temperatures (less than 20 degrees Centigrade) and dissolved oxygen concentrations greater than 4 mg/l:

Cisco	Coregonus artedi

Cisco were known historically from five lakes in the upper Turkey Creek watershed (Shock Lake, Knapp Lake, Gordy Lake, Hindman Lake, and Indian Village Lake).

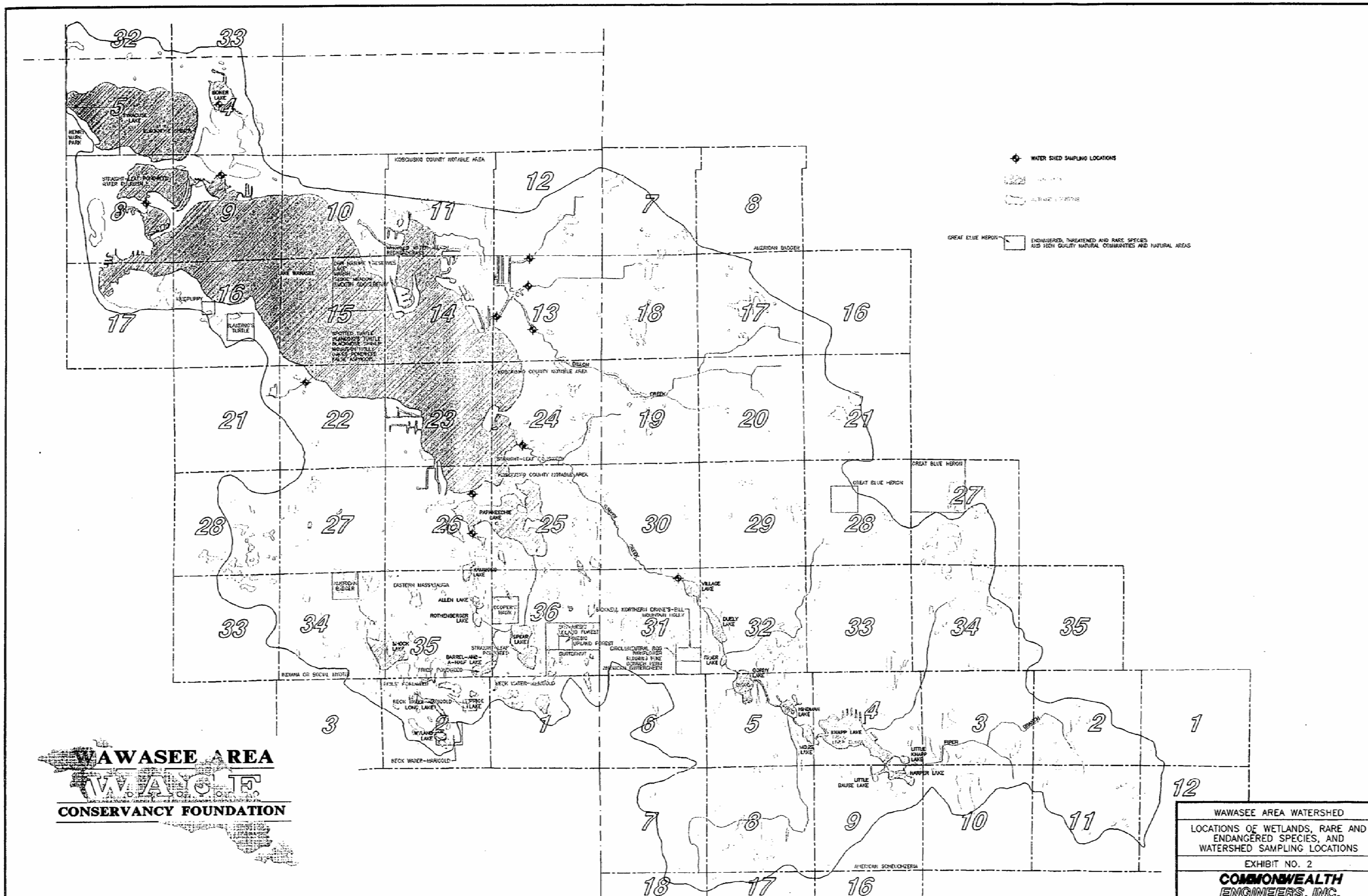
The last survey taken by IDNR in 1988 showed that only Gordy Lake still supports a remnant population of this rare fish.

Specific requirements for the conservation of the remaining aquatic endangered, threatened, or rare species in the watershed basically consist of preservation of wetland and aquatic habitats.

Exhibit 2 is a map of wetland areas and the locations of endangered, threatened, and rare species.

c. In addition to the above listed species that were obtained from the IDNR Division of Nature Preserves database, a lake sturgeon (Acipenser fulvescens) was recently caught from Lake Wawasee by an angler.

5. The wetland draining activities in the WAW and along lake margins are the primary reasons many of the above listed species are rare, threatened or endangered. Preservation of wetland habitats not only preserves the species of concern but also preserves the water quality of WAW lakes. Particularly in the Johnson Bay area where several species of concern now live. Alteration of the lake margin wetland systems could have major ecological impacts. Implementation of watershed treatments may enhance the suitability of habitats for the species of concern.


WATER SHED SAMPLING LOCATIONS
GREAT BLUE HERON
ENDANGERED, THREATENED AND RARE SPECIES
AND HIGH QUALITY NATURAL COMMUNITIES AND NATURAL AREAS
LAKE WAWASEE
SYRACUSE LAKE
KOSCIUSKO COUNTY NOTABLE AREA
BLANDING'S TURTLE
PAPAKEECHIE LAKE
VILLAGE LAKE
ALLEN LAKE
ROTHENBERGER LAKE
SPIDER LAKE
COOPER'S HAWK
EASTERN MASSASAUGA
AMERICAN BADGER
AMERICAN SCHEUCHZERIA
HARPER LAKE
KNAPP LAKE
LITTLE KNAPP LAKE
HINDMAN LAKE
LITTLE BAUSE LAKE
WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION
WAWASEE AREA WATERSHED
LOCATIONS OF WETLANDS, RARE AND ENDANGERED SPECIES, AND WATERSHED SAMPLING LOCATIONS
EXHIBIT NO. 2
COMMONWEALTH
ENGINEERS, INC.

Section III

Compilation and Synopses of Previous Studies

III. COMPILATION AND SYNOPSES OF PREVIOUS STUDIES

The following previously performed studies on the water quality of Lake Wawasee were compiled and summarized to provide a synopsis of all available, previously collected, data on the water quality of Lake Wawasee. The Wawasee Area Conservancy Foundation (WACF) provided assistance in gathering these reports. The reports are presented in chronological order. A Volume II, Lake Wawasee Compilation of Previous Studies and Reports is a bound collection of reports pertaining to the water quality of the Wawasee Area Watershed and is a supplement to this report provided to the WACF.

Hay 1895. A report on the initial findings of an aquatic research station established in Vawter Park on Lake Wawasee by Indiana University. The former Vawter Park is now the site of the South Shore Condominiums.

Blatchley 1898. Describes the Lake Wawasee area and geography.

Scott et al. 1928. A report on the numbers and types of animals inhabiting the bottom substrates of Lake Wawasee. The authors found that midge larvae predominated and that the lake bottom supported nearly 400 kg of biomass per hectare of lake area. They considered this volume of biomass rather high, indicating that the lake was fairly productive.

Marshall. 1929. A study of the water mites of Lake Wawasee. The author found a total of 27 species and described 4 new species. Because these animals were first taxonomically described from Lake Wawasee specimens, the lake is the "type locality" for the water mites Limnesia wawaseea, Libertia quinquemaculosa, Atractides indistinctus, and Neumania pubescens.

Lomax. 1967. The author studied Bonar Lake and described its morphology and some of its wetland areas. The author also performed an inventory of macro and micro organisms in the lake. The lake had low bacterial counts and was anoxic below about 15 to 20 feet during the summer.

Gifford et al. 1971. A study of phosphorus and fecal coliform bacteria levels in Lake Wawasee. The highest phosphorus levels (0.09 mg/l) found in the lake were near Morrison Island on the south end. Fecal coliform levels were not high enough to be of concern within the lake but were higher in the artificial boat channels and in Turkey Creek. The authors attributed higher fecal coliform levels to improper disposal of sewage from boats.

Shaffer. 1974. Another study of bacteria and nutrients within Lake Wawasee. The author also found elevated levels of both in the boat channels of near shore areas. Reported concentrations of nutrients and bacteria were much higher than previous or subsequent studies.

Shipman, 1975. IDNR fisheries biologists collected fish from Lakes Syracuse and Wawasee during 1975 to determine species composition and abundance. Below is a list of species and numbers of individuals in the 1975 composited with the 1985 fishery surveys for both lakes Syracuse and Wawasee. In Mr. Shipman's comments he points out the need to protect the fish (northern pike specifically) nursery habitats of Johnson Bay and Conklin Bay.

Editor's Note: 1975 and 1985 fishery survey data is presented together for general interest. Differences between 1975 and 1985 species abundance basically reflect differences in sampling effort or population dynamics rather than indicators of changing environmental conditions. Due to differences in the sampling effort time and slight differences in sampling techniques the data cannot be directly compared (for example, gill net efforts were approximately four times greater in 1975 than 1985).

Lake Wawasee Number Collected

Common Name	1975	1985
Bluegill	452	333
Yellow perch	287	99
Largemouth bass	129	126
Black crappie	127	21
Redear	95	45
Brown bullhead	43	25
Pumpkinseed	105	9
Longnose gar	74	43
Lake chubsucker	70	11
Yellow bullhead	41	25
Northern pike	31	34
Longear	64	18
Warmouth	39	17
Spotted gar	38	7
Brook silverside	44	(common)
Grass pickerel	11	4
Green sunfish	6	
Bowfin	26	6
Rock bass	36	3
Golden shiner	15	14
Smallmouth bass	13	19
Carp	2	4
Bluntnose minnow	5	2
Logperch		4
Banded killifish	4	1
Emerald shiner	86	
Walleye	9	

Syracuse Lake Number Collected

Common Name	1975	1985
Bluegill	499	552
Yellow perch	32	189
Largemouth bass	50	193
Black crappie	53	13
Redear	80	139
Brown bullheads	51	25
Pumpkinseed sunfish		16
Longnose gar	32	27
Lake chubsucker	30	9
Yellow bullhead	23	22
Northern pike	16	4
Longear	16	6
Warmouth	12	23
Spotted gar		1
Brook silverside	2	3
Grass pickerel	14	3
Green sunfish	8	6
Bowfin	3	1
Rockbass	7	
Golden shiner	4	2
Smallmouth bass	2	
Carp	1	
Bluntnose minnow	1	
Logperch	2	
Banded killifish	1	
Central mudminnow	5	

Editor's Note: In the 1975 fishery surveys the reporting biologist noted anglers commonly kept a large percent of bass species caught (no minimum size limits were in effect for largemouth or smallmouth bass), he reported the predator prey relationship as unbalanced. The 1985 fishery surveys reported a balanced predator prey relationship even though there were still no minimum size limit on black basses. The biologist reported the balanced relationship was likely due to fewer bass being harvested through increasingly popular "catch and release" bass fishing. Between 1975 and 1985 there were three separate attempts to stock walleyes into Lake Wawasee. Presently there is a 12 inch minimum size limit in effect for black basses. A new fishery survey is scheduled for 1997 for both lakes Wawasee and Syracuse.

Kiley & Dineen. 1981. A report on the occurrence and distribution of four species of crayfish found in Lake Wawasee.

Keiper. 1982. The author reported on elevated levels of fecal coliform bacteria and ammonia entering Lake Wawasee from Lake Papakeechie.

Pearson. 1985. IDNR fisheries biologists collected fish from Lake Wawasee during 1985 to determine whether walleye stocking was successful. The report noted that bluegill, largemouth bass, and yellow perch were the most abundant fish in the lake. The most "biomass" was contributed by northern pike. Small numbers of walleye were observed. See the results on the preceding page.

Keiper. 1989 and 1990. These two reports summarize the findings that blue-green algae blooms occurred in certain areas of Lake Wawasee during June 1989 and May 1990.

Spacie & Loeb. 1990. Long-term monitoring of 15 lakes in Indiana showed that Lake Wawasee was one of only 2 lakes in the State with "permissible" loadings of phosphorus (loadings which should not contribute to unnatural "eutrophication" associated with having the lake becoming unusually algae-enriched prematurely).

Indiana Department of Environmental Management. 1990. Included in this report on water quality throughout Indiana are data on the trophic status of Indiana Lakes. The Eutrophication Index used by IDEM is a value used to rank the "trophic status" of lakes (how algae-enriched they are). The Index ranges from 0 to 75, with higher numbers indicating a higher potential for algae-related problems. The Index Value for Lake Wawasee in 1976 was 18, while in 1987 it was 7. Both values fell in Trophic Class One, representing lakes with the highest water quality in Indiana. Index Values reported for other lakes in the watershed did not have dates associated with the trophic index studies. The trophic data on other WAW lakes is presented below.

Lake Name	Trophic Index Value	Trophic Class
Bonar Lake	43	Class Two
Syracuse Lake	4	Class One
Shock Lake	28	Class Two
Duely Lake	42	Class Four*
Gordy Lake	43	Class Two
Hindman Lake	52	Class Four*
Knapp Lake (1987)	29	Class Two
Knapp Lake (1970's)	43	Class Two
Moss Lake	51	Class Four*
Indian Village Lake	59	Class Four*
Rider Lake	55	Class Four*
Lake Wawasee (1976)	18	Class One
Lake Wawasee (1987)	7	Class one

* Class Four lakes are relatively shallow lakes with a predominance of submergent aquatic vegetation that cover the lake bottom and reach to the surface over at least 30% of the surface area. (More explanation of Trophic Classes is found in Section II of this report.)

Keiper. 1992. A survey of fecal coliform bacteria during the summer of 1992 found that fecal coliforms were very abundant (too numerous to count) on three occasions in the Turkey Creek and Papakeechie Lake inlets to Lake Wawasee. Standard methods for bacterial analysis were used.

Stanger and St. Cair, 1995. Enchanted Hills Watershed Evaluation, a joint study by the Kosciusko and Noble County Natural Resource Conservation Service offices in cooperation with the Enchanted Hills watershed Task Force, studied the Dillon Creek watershed and made recommendations to apply land treatments in combination with structural controls, to reduce sediment loading from Dillon Creek to Lake Wawasee. The estimated cost of their recommended project was about $275,000. Most of this cost was in structural controls.

Environmental Health Lab. 1994. Two sites on Papakeechie Lake were examined for EPA Priority Pollutants and fecal coliform bacteria. No problems were observed at either site.

Horvath et al. 1994. The authors studied the density of adult zebra mussels in Lakes Wawasee and Syracuse. Densities as high as 4,214 adults per square meter of hard substrate were observed in Lake Wawasee during the summer of 1993. Densities decreased rapidly in Turkey Creek downstream from Syracuse Lake.

Garton. 1994. There are native mussels present in Lake Wawasee, and the author studied the effect of introduced zebra mussels on survival of the native fauna. Zebra mussels were found growing on all native mussel shells, but the rate of encrustation was less severe than reported for several other lakes. Zebra mussel encrustation was considered to have the potential to wipe-out native mussels in the lake.

Ind. Univ. School of Public and Environmental Affairs. 1994. This report is a summary of Indiana volunteer lake monitoring results using Secchi disk measurements of water transparency. Lake Wawasee has been monitored regularly since 1989. The five-year average Secchi depth for the lake is 10.4 feet, with no significant increasing or decreasing trends over time. This degree of transparency falls into the "good" range of water quality. The report also includes data on total phosphorus and "chlorophyll a" collected during 1992 and 1993 by volunteers.

Soster and Harvey. 1994. These two researchers from DePauw University have been monitoring Lake Wawasee sediments for heavy metals and sedimentation rates. Their data has not yet been published, but they furnished summary tables. The sedimentation rate in June 1994 was 0.69 cm/yr in the south basin and 0.31 cm/yr in the north basin. Core samples of sediment show that copper, lead, and zinc concentrations in lake sediments were relatively low at the turn of the century (less than 20 ug/g), reached a peak in the early 1980's (up to 110 ug/g) and appear to be declining once again. (Perhaps due to implementation of the Clean Air Act)

East Noble High School. 1995. A class at East Noble High School monitored several sites on Lake Wawasee tributaries for nutrients. Their results were submitted to the Noble County Soil and Water Conservation District (c/o Doug Nusbaum), who forwarded them to Commonwealth.

Section IV

Discussion of Watershed Land Use and Mapping

IV. DISCUSSION OF WATERSHED LAND USE AND MAPPING

A. The Wawasee Area Watershed

The Wawasee Area Watershed (WAW) is among the largest lake watersheds in Indiana at 24,000 acres. Presently it is one of the highest quality watersheds in the state, primarily because of the large amount of wetlands acres in the watershed. On Exhibit 2 in Section II, note the green outlined areas on the map, representing the locations of wetlands in the watershed.

A watershed is the lake drainage basin (that catchment area where, if a drop of water falls within the basin it has the opportunity to flow into the lake). A delineation of the WAW is illustrated on Exhibit 1 in Section II.

An often used phrase in lake and watershed management today is "A Lake is a Reflection of its Watershed"; this is very true. The composition and character of the watershed is the primary factor in dictating the composition and character of a water body.

To get to a lake, water vapor must first condense on a particulate (dust particle) in the atmosphere, form a water molecule, and then fall to earth as precipitation on either land or water. Water is called the universal solvent. Given enough water, velocity, and/or time, it can dissolve nearly everything.

If a water molecule falls on the land, it then travels over and through the materials that cover the land. On its way downhill to a body of water, a water molecule, or groups of molecules, pick up and carry a variety of substances with it. Most of these substances are considered nonpoint sources of pollution and contribute to the eutrophication process.

Most naturally occurring ground covers and land uses are the most protective type of cover to protect the land and water bodies from the erosive effects of moving water. Many of the ways people alter the landscape, including ground cover alterations and land use conversions compromise the natural ability of the land and water bodies to protect themselves from the erosive and dissolving effects of water moving through the environment (thus, cultural eutrophication).

Wetlands perform many functions in the environment. One primary function is to function as a filtering system for water entering them. The water leaving a wetland is generally far cleaner than the water that enters it. Wetlands function as a kidney in the landscape, trapping sediment and nutrients entering the wetlands and releasing clean water downstream and/or pumping water vapor into the atmosphere through evapotranspiration.

B. Analysis of the Wawasee Area Watershed (WAW)

This report section is devoted to a description of land uses in the watershed. This discussion is based on the findings of the watershed field evaluation and examination of aerial photographs.

Each square mile (640 acres or 1 section) of the watershed has been analyzed regarding the land uses of the entire Wawasee Area Watershed (WAW). The results of this analysis are mapped on Exhibit 6 in Section XII.

The most recent, scalable aerial photographs of the watershed were obtained by Commonwealth. The most recent aerial photos for Kosciusko County were taken in 1991. The most recent aerial photos for Noble County were taken in 1994. These were obtained from the Surveyor's office of the respective County. These photos were examined to determine land uses and identify areas which appear to be sources of erosion or other water quality degradation.

C. Mapping of WAW Land Use

Information obtained from these photos on possible non-point source "hotspots" were field verified and plotted on the Hotspots map included on Exhibit 6 in Section XI. Land use information from the aerial photos and from the aerial reconnaissance were used to further refine the Watershed Land Use Map.

A Watershed Land Use Map (Exhibit 6, Section XI) was developed to depict the major land uses in the watershed and plot them with other features such as Highly Erodible Land (HEL), wetlands, sampling locations, and waterways. The watershed basically has five major land use types. These land uses include:

1. Agriculture
   a. cropland
      - conventionally tilled vs. conservation tillage
   b. livestock production
      - confined vs. unconfined production
   c. pasture
      - hayland, idle land, and grazed conservation reserve program land

2. Lakes, wetlands, and streams

3. Wildlife Habitat
   a. Tri-County Fish and Wildlife Area and Private Landowners
      - Wetlands
      - Idle Conservation Reserve Program (CRP) land
      - Forests
      - Cultivated Small Grains for Wildlife forage

4. Residential
   a. Farmstead
   b. Subdivisions and Lake Communities

5. Urban
   a. Commercial
   b. Industrial

c. Higher density residential

Most of the upland portions of the WAW are in agricultural production, primarily cropland for cash grains. Fortunately most of the cropland is in a conservation tillage and/or in a crop rotation that helps to considerably reduce the potential for off-site erosion or transport of nutrients during non-growing seasons. A small portion of the watershed is also in the Conservation Reserve Program.

The portions of the Turkey Creek subwatershed nearer the waterways fortunately is composed primarily of wetland habitat. The wetlands serve to filter the sediments and nutrients from the overland runoff and to assimilate the nutrients from the runoff into plant biomass. The soils of wetlands have a high carbon content from dead plant detritus. This high carbon soil tends to function as a charcoal filtering system with pollutants adsorbing to the carbon molecules. Wetlands are often referred to as a nutrient "sink', due to the characteristic of wetlands to discharge water with concentrations of pollutants far less than the water that came into the wetland system.

A small portion of highly erodible acres is presently in CRP, the CRP contracts will expire on approximately 90% of the CRP ground in the next 1 to 2 years. It is imperative that conservation measures are installed on this HEL prior to the land being put back into crop production. The Wawasee Area Conservancy Foundation (WACF) can work with the local District Conservationists to recruit landowners to put acreage in the CRP program or to develop cost-share programs for landowners to implement best management practices on their land.

D. <u>County Land Use Planning</u>

Presently both Kosciusko County and Noble County have comprehensive land use plans for their counties but the plans do not include special provisions or ordinances concerning protection of aquatic resources. Both county governments should develop ordinances and specific land use plans that provide for the protection of water resources from cultural pollution.

The WACF should work through a larger lakes council body, such as the Kosciusko County Lakes Council or the Indiana Lake Management Society, to encourage county officials to develop and adopt enforceable land use plans that protect water bodies from degradation due to land use activity.

Section V

Calculation of Water Budget

V. CALCULATION OF WATER BUDGET

A. Explanation of Methods

A water budget of Lake Wawasee was developed to estimate the inflow rate, outflow rate, and residence time of lake water. This information was previously calculated in other studies on Lake Wawasee. These data were presented to prevent duplicating existing data. The estimated rates of groundwater recharge or discharge to and from Wawasee Area Watershed (WAW) lakes is not available and have thus been left out of the water budget.

The water budget estimated the quantity of water contributed from each surface water source such as:

- streams
- major springs
- rainfall

The quantity of water leaving Lake Wawasee and Syracuse Lake through the Turkey Creek Dam also was obtained. The withdrawals estimated include outflow from the Turkey Creek Dam, and private water use around Lake Wawasee including irrigation water. A brief discussion of irrigation return flow impact is also presented. A discussion of other private water uses is included in this section as well.

An estimate of the amounts and sources of surface water entering a lake is made by evaluating drainage areas and flow records from nearby streams. The only stream gauging station in the Turkey Creek watershed is located near the outlet of Syracuse Lake. According to United States Geologic Survey (USGS) gauging station records (Arvin, 1989), Turkey Creek at this point has an average annual flow of 37.9 cubic feet per second and a drainage area of 38 square miles. By extrapolating the flow at the Syracuse Lake outlet to other points in the watershed using drainage area data (Hoggatt, 1975), the average flow of water feeding Lake Wawasee and Syracuse Lake from various sources is presented in Table 3.

B. Results and Discussion

Table 3
Lake Wawasee Water Budget Estimate* (Surface Water Only)

	Drainage Area (sq. mi.)	Average Flow (cfs)
Turkey Creek Inlet	15.9	13.7
Dillon Creek		
Norris Branch	0.8	0.7
Launer Ditch	2.1	1.8
Dillon Creek	2.6	2.3
Lake Papakeechie Inlet	5.5	4.8
Bonar Lake Inlet	0.5	0.4
Direct Precipitation	4.1	3.5
Local Runoff	5.4	4.7
TOTAL	36.9	31.9

* Estimate based on drainage size only. Does not account for differing topography or land cover.

According to Spacie and Loeb (1990), the hydraulic retention time of water within Lake Wawasee is 3.5 years. Evaporation was assumed to be negligible in the Spacie and Loeb report. According to the Water Encyclopedia (1992) evaporation for the WAW region is approximately 31 inches per year. Over the 3,410 acre surface of Lake Wawasee this is 8,808 acre feet per year or 0.000036% of the Lake Wawasee volume. Therefore, omitting evaporation from the water budget is legitimate, especially considering the offsetting effects of dewfall to evaporation losses.

The total volume of Lake Wawasee is estimated by the following equation:

Mean depth X Surface area = Estimated Volume

Where:

Mean Depth = 22 feet (ft)
Surface Area = 3,410 acres (148,520,000 ft^2)
One Acre Foot (ac. ft.) = 325,829 gallons (.326 X 10^6 gallons)

Therefore:

22 ft X 3,410 ac. ft. = 75,020 ac. ft. (Lake Wawasee capacity)

And: 75,020 ac. ft. X 325,829 gals/ac. = 24,444,000,000 gallons of capacity

According to the Indiana Department of Natural Resources (IDNR) Division of Water, there are two registered surface water withdrawal facilities in Lake Wawasee. IDNR records for 1991-93 show that the Wawasee Golf and Country Club uses approximately 170,000 to 290,000 gallons of lake water per year for irrigation. The South Shore Golf Course uses an additional 24 to 40 million gallons per year for irrigation. Therefore, from 24,170,000 to 40,290,000 gallons per year are withdrawn from Lake Wawasee for commercial lawn irrigation for these two users. This withdrawal of water extends the flushing rate.

Extension of the flushing rate results in the prolonging of the residence time of pollutants in the water. Extension of the residence time of pollutants is not good for water quality. Once a lake with a slow flushing rate becomes polluted, it takes much longer for a reversal or an improvement of water quality to become apparent from lake enhancement treatments. In addition to a long flushing rate, Lake Wawasee is relatively deep with a relatively large volume. Thereby, the lake can absorb a lot of pollution before its effects are apparent. There is a delayed response between introduction of pollutants and a degradation of water quality.

Based on the above Lake Wawasee volume calculations, the percentage of water permitted to be withdrawn from Lake Wawasee for irrigation purposes is from 0.099% to 0.165% of the total lake volume. There is no estimate of the quantity or quality of return flows (if any) re-entering Lake Wawasee specifically from this irrigation activity.

Table 4
Syracuse Lake Water Budget (Surface Water Only)

	Drainage Area (sq. mi.)	Average Flow (cfs)
Lake Wawasee Inlet	36.9	31.9
Direct Precipitation	0.9	0.8
Local Runoff	0.4	0.4
TOTAL	38.2	33.1

C. Groundwater Flow

The groundwater budget for the WAW has not been quantified and would be extremely difficult to quantify. It is assumed to be balanced based on regional geology. Because the geology of the watershed is rather homogenous (see the geology section of background considerations), the flow of groundwater into and then out of the watershed system is assumed to be balanced. This assumption of a groundwater balance is based on observations from a variety of published research:

- The bedrock of the area is homogenous Devonian and Mississippian shale and relatively level.
- The unconsolidated deposits are relatively level throughout the watershed at approximately 350 feet deep.

- The unconsolidated deposits are relatively level throughout the watershed at approximately 350 feet deep.

- The potentiometric head is relatively constant throughout the watershed as well as the area surrounding the watershed. This groundwater head appears to be independent of the surficial geological features such as Turkey Creek and the lakes of the WAW.

- Individual well logs from IDNR Division of Water records indicate that in the vicinity of the Syracuse Lake Dam, groundwater elevations average approximately 850 feet above sea level. In the upper reaches of the watershed (near Knapp Lake), the groundwater elevation is approximately 875 to 880 feet above sea level.

- The groundwater flow direction generally follows the same pattern of surface water flow throughout the St. Joseph River drainage basin.

- An 1898 report (Blatchley and Ashley) listed the location of several springs along the upper half (southeastern portion) of Lake Wawasee, and none along the lower half (northwestern portion).

Section VI

Watershed Soils Report and Mapping of Highly Erodible Soils

VI. WATERSHED SOILS REPORT AND MAPPING OF HIGHLY ERODIBLE SOILS

A study of the soils in the watershed was conducted to determine the locations and areal extent of Highly Erodible Land (HEL) in the Wawasee Area Watershed (WAW). A map illustrating the locations and extent of identified areas with HEL was developed. It is included as Exhibit 3 on page VI-7. along with the waterways and wetland locations in the watershed. Mapping of HEL in relation to land use is presented in Exhibit 6 on page XII-5.

A general description of the soils in the watershed follows. In addition, generalized soil maps of the Wawasee Area Watershed (WAW) for both Kosciusko and Noble Counties are included as Figures 1 and 2 respectively. This soils report and Figures 1 and 2 are based on published United States Department of Agriculture (USDA) soil survey mapping and information from District Conservationists in the watershed. Most watershed soils are sandy loams, very permeable, composed of dense large particles that are relatively stable with respect to resistance to erosive forces.

A. Kosciusko County Soils

The WAW soils in Kosciusko County are of four predominant general classifications:

- Houghton - Palms association: Mucky, poorly drained soils formed in organic material
- Ormas - Kosciusko association: Sandy and Loamy, well drained soils on glacial outwash deposits.
- Crosier - Barry association: Loamy, somewhat poorly drained soils formed in glacial till.
- Sebewa - Gilford association: Loamy, poorly drained to very poorly drained soils, formed in glacial outwash deposits.

In lake and watershed management, the soils types of a watershed are a critical element from a management perspective. The prevention or reduction of non-point source (NPS) pollution begins with identifying highly erodible soils and determining best management practices (BMPs) for stabilizing highly erodible land (HEL). The highly erodible soil series (Class I) and potentially highly erodible soil series (Class II) for the Kosciusko County portion of the WAW are listed in Table 5 below. The location of these soils are also depicted on the map in Exhibit 3 page VI-7.

Table 5
Kosciusko County Soils Of The WAW

Class I, Highly Erodible Soils		Class II, Potentially Highly Erodible Soils	
Soil Name	Mapping Symbol	Soil Name	Mapping Symbol
Boyer	BoC	Miami	MsB

Class I, Highly Erodible Soils		Class II, Potentially Highly Erodible Soils	
Soil Name	**Mapping Symbol**	**Soil Name**	**Mapping Symbol**
Coloma	ClC	Morley	MZb
Kosciusko	KoC		
Kosciusko	KoE		
Kosciusko	KxC3		
Martinsville	MaC		
Metea	MbC		
Miami	MlC		
Miami	MrC3		
Miami	MrD2		
Miami	MsD		
Owosso	MSD		
Metea	MSD		
Morley	MVC		
Morley	MCX3		
Morley	MXD3		
Morley	MZB		
Ormas	ORC		
Ormas	OTC		
Riddles	RLC		
Riddles	RLD		
Riddles	RXC		
Ormas	RXC		
Kosciusko	RXG		
Wawasee	WLC2		
Wawasee	WLD2		

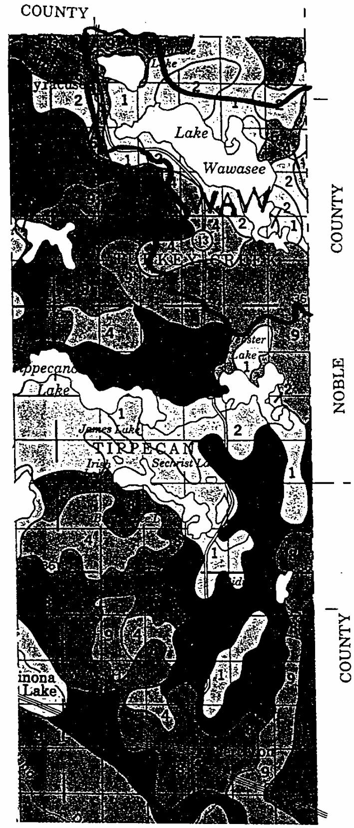
UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

KOSCIUSKO COUNTY, INDIANA

Scale 1:190,080

1 0 1 2 3 Miles



SOIL LEGEND*

DOMINANTLY NEARLY LEVEL AND DEPRESSIONAL SOILS THAT ARE VERY POORLY DRAINED; ON UPLANDS

1 — Houghton-Palms association: Mucky soils that are very poorly drained and formed in organic material; on uplands

DOMINANTLY NEARLY LEVEL TO MODERATELY SLOPING SOILS THAT ARE WELL DRAINED; ON UPLANDS

2 — Ormas-Kosciusko association: Sandy and loamy soils that are well drained and formed in outwash deposits; on uplands

3 — Shipshe-Carmi association: Loamy soils that are well drained and formed in outwash deposits; on uplands

DOMINANTLY NEARLY LEVEL, GENTLY SLOPING, AND DEPRESSIONAL SOILS THAT ARE SOMEWHAT POORLY DRAINED TO VERY POORLY DRAINED; ON UPLANDS

4 — Crosier-Barry association: Loamy soils that are somewhat poorly drained and poorly drained and formed in glacial till; on uplands

Rensselaer-Whitaker association: Loamy soils that are very poorly drained and somewhat poorly drained and formed in lacustrine sediments; on uplands

6 — Sebewa-Gilford association: Loamy soils that are poorly drained and very poorly drained and formed in outwash deposits; on uplands

DOMINANTLY NEARLY LEVEL TO STEEP SOILS THAT ARE WELL DRAINED; ON UPLANDS

Riddles-Ormas-Kosciusko association: Loamy and sandy soils that are well drained and formed in glacial till and outwash deposits; on uplands

8 — Riddles-Wawasee association: Loamy soils that are well drained and formed in glacial till; on uplands

DOMINANTLY NEARLY LEVEL TO MODERATELY STEEP SOILS THAT ARE WELL DRAINED AND SOMEWHAT POORLY DRAINED; ON UPLANDS

9 — Wawasee-Crosier-Miami association: Loamy soils that are well drained and somewhat poorly drained and formed in glacial till; on uplands

Morley-Blount association: Loamy and silty soils that are well drained and somewhat poorly drained and formed in glacial till; on uplands

*Texture terms in the descriptive headings refer to the surface layer of the major soils in the associations.

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FIGURE 1
Kosciusko County
Generalized Soil Map

B. Noble County Soils

The WAW soils in Noble County are of three predominant general associations:

- Miami-Riddles-Brookston Association: Well drained to very poorly drained, nearly level to moderately steep, deep soils that have a moderately fine textured subsoil, primarily on uplands. Found in the upland agricultural areas of the watershed.

- Fox-Oshtemo association: Well drained, nearly level to moderately steep soils that have a moderately coarse to moderately fine textured subsoil and are moderately deep over sand and gravel glacial outwash. Primarily found on the rolling agricultural southern portions of the watershed.

- Houghton-Edwards-Adrian association: Very poorly drained , nearly level mucks, that are deep or moderately deep over marl or sand and gravel. Found primarily in the extensive wetland portions of the Turkey Creek subwatershed.

The highly erodible soil series (Class I) and potentially highly erodible soils series (Class II) are listed in Table 6 below. The highly erodible soils of Noble County are mapped on Exhibit 3, page VI-7.

Table 6
Noble County Soils Of The WAW

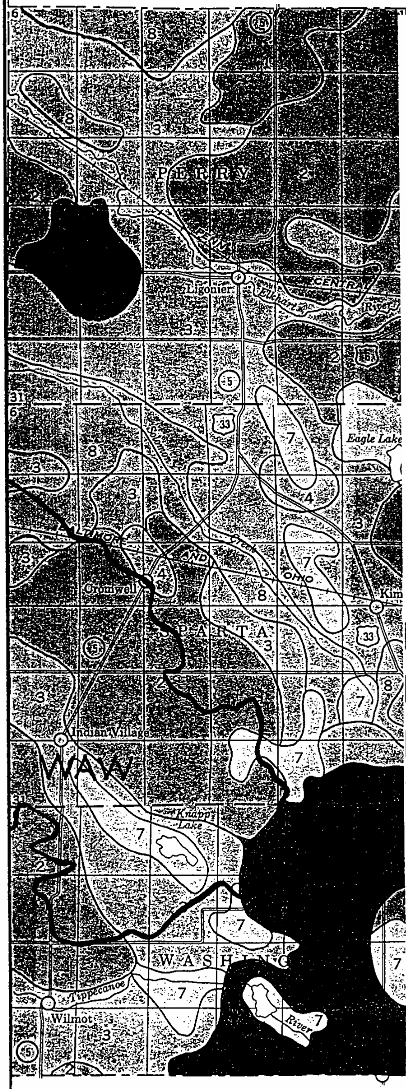
Class I, Highly Erodible Soils		Class II, Potentially Highly Erodible Soils	
Soil Name	**Mapping Symbol**	**Soil Name**	**Mapping Symbol**
Boyer	BoD2	Blount	BiB2
Casco	CcC3	Boyer	BoB
Casco	FsD2	Boyer	BoC
Fox	FsD2	Chelsea	ChC
Fox	FsE2	Fox	FoB
Casco	FsE2	Fox	FoC2
Miami	MfD2	Martinsville	MdB
Miami	MfE2	Miami	MfB2
Miami	MgC3	Miami	MfC2
Miami	MgD3	Miami	MhB2
Morley	MrD2	Morley	MrB2

Class I, Highly Erodible Soils		Class II, Potentially Highly Erodible Soils	
Soil Name	**Mapping Symbol**	**Soil Name**	**Mapping Symbol**
Morley	MsC3	Morley	MrC2
Morley	MsD3	Riddles	RsB
Morley	MtE*	Riddles	RsC2
Morley	MuC2	Sebewa	Se
Miami	MuC2		
Rawson	MuC2		
Oshtemo	OsC		
Rawson	RaC2		
Rawson	RbB		
Rawson	RdB2**		
Morley	RdB2**		
Miami	RdB2**		
Riddles	RsD2		

* See page 34 of Noble County Soil Survey
** See page 39 of Noble County Soil Survey

In summary, while there is a considerable amount of highly erodible soils throughout the watershed, based on visual inspection, most appears to be relatively stable due to well managed ground cover. Most of the tilled highly erodible acres in the WAW are presently in a conservation tillage practice. A small portion of the HEL land in the WAW is in the Conservation Reserve Program (CRP). A large percent of the highly erodible land in a conservation tillage practice also have other erosion control features installed such as grassed waterways and filter strips. Some even have water and sediment control basins (WASCOBS) installed.

A large area of conventional tilled land is located along Launer Ditch and Dillon Creek in the Enchanted Hills sub-watershed. This area needs to be better stabilized with grassed waterways, filter strips, and stream bed grade stabilization in ephemeral sections of the streams. More detail on the Enchanted Hills Subwatershed is included in the problem areas section.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

NOBLE COUNTY, INDIANA

Scale 1:126,720

1 0 1 2 3 4 Miles

SOIL ASSOCIATIONS

MODERATELY DEEP OR DEEP, WELL DRAINED TO VERY POORLY DRAINED NEARLY LEVEL TO MODERATELY STEEP MINERAL SOILS THAT HAVE A MODERATELY COARSE TEXTURED TO FINE TEXTURED SUBSOIL; ON UPLANDS OR OUTWASH PLAINS

1 Warsaw-Parr association: Well drained, nearly level soils that have a dominantly moderately fine textured subsoil and are moderately deep and deep over sand and gravel; on outwash plains and uplands

2 Miami-Riddles-Brookston association: Well drained and very poorly drained, nearly level to moderately steep, deep soils that have a moderately fine textured subsoil; on uplands

3 Fox-Oshtemo association: Well drained, nearly level to moderately steep soils that have a moderately coarse textured to moderately fine textured subsoil and are moderately deep and deep over sand and gravel; on outwash plains and uplands

Morley-Blount association: Well drained to somewhat poorly drained, nearly level to moderately sloping, deep soils that have a fine textured and moderately fine textured subsoil; on uplands

5 Morley-Miami association: Well drained or moderately well drained, moderately sloping to moderately steep, deep soils that have a moderately fine textured or fine textured subsoil; on uplands

MODERATELY DEEP OR DEEP, SOMEWHAT POORLY DRAINED TO VERY POORLY DRAINED, NEARLY LEVEL MINERAL AND ORGANIC SOILS THAT HAVE A MODERATELY FINE TEXTURED OR FINE TEXTURED SUBSOIL OR ORGANIC MATERIAL: ON UPLANDS OR OUTWASH PLAINS

6 Haskins-Toledo association: Somewhat poorly drained and very poorly drained, nearly level, deep soils that have a moderately fine textured or fine textured subsoil; on outwash plains and uplands

7 Houghton-Edwards-Adrian association: Very poorly drained, nearly level mucks that are deep or moderately deep over marl or sand and gravel; in depressions on uplands or outwash plains

8 Homer-Sebewa association: Somewhat poorly drained and very poorly drained, nearly level soils that have a moderately fine textured subsoil and are moderately deep over sand and gravel; on outwash plains

Compiled 1976

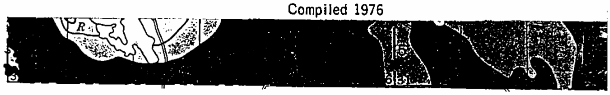


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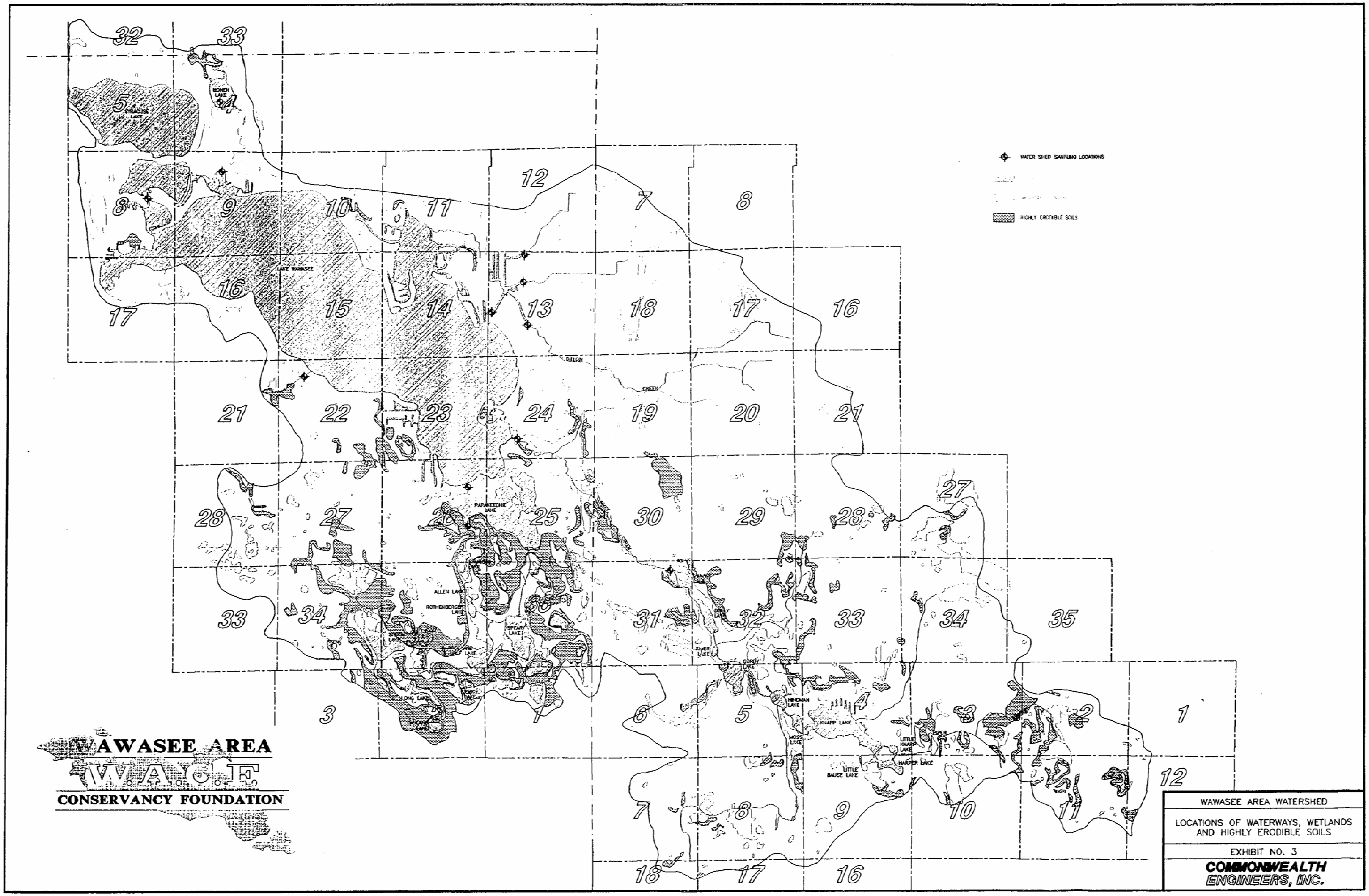
FIGURE 2
Noble County
Generalized Soil Map


WATER SHED SAMPLING LOCATIONS
HIGHLY ERODIBLE SOILS
SYRACUSE LAKE
LAKE WAWASEE
DILLON CREEK
PAPAKEECHIE LAKE
ALLEN LAKE
ROTHENBERGER LAKE
SPEAR LAKE
KNAPP LAKE
HINDMAN LAKE
HARPER LAKE
LITTLE BAUSE LAKE
WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION
WAWASEE AREA WATERSHED
LOCATIONS OF WATERWAYS, WETLANDS
AND HIGHLY ERODIBLE SOILS
EXHIBIT NO. 3
COMMONWEALTH
ENGINEERS, INC.

Section VII

Watershed Water Quality Sampling

VII. WATERSHED WATER QUALITY SAMPLING

A. Introduction

Direct measurement of non-point source pollution inputs to the lakes and streams of the watershed were performed to quantify the amount of pollutants (primarily sediments and nutrient) being transported through the watershed. Watershed chemical sampling was done for both base flows (dry period conditions) and stormwater flows after rain events of sufficient magnitude to generate runoff.

Watershed sampling points were selected with the assistance of the Wawasee Area Conservancy Foundation (WACF), Ecology Committee. For each sampling site three samples were taken for both base flow and high flow events. The concentrations of each parameter were then compared to each other across storm events for a comparative analysis of relative nutrient and sediment loadings to the lakes from the watershed.

The sampling of tributary streams was performed both in the spring (before crops were planted) and in early summer (after crops had been planted).

Multiple sampling, as described above, was performed to quantify watershed-wide inputs of direct nutrient and sediment delivery to Lake Wawasee via tributaries. Watershed water sampling was performed at the following locations and frequencies:

Table 7
Planned Sampling Sites and Timing

Locations	Spring/Early Summer Base Flows	Spring/Early Summer High Flows	Summer Stratification
South Shore Golf Club Tributary (WACF will notify when to sample based on the discharge rate)*		3 Samples	
Dillon Creek at Outlet - into Enchanted Hills Channels	3 Samples	3 Samples	
- outlet of channels into Lake	3 Samples	3 Samples	
Turkey Creek - at Indian Village	3 Samples	3 Samples	
- at Outlet	3 Samples	3 Samples	

Locations	Spring/Early Summer Base Flows	Spring/Early Summer High Flows	Summer Stratification
Boat Access Channels (selected by the WACF Ecology Committee) (Escherichia coli samples taken after a high use weekend)**			1 Sample Each
Outlet of Lake Papakeechie		1 Sample	
Inlet of Lake Papakeechie		1 Sample	
Outlet of Bonar Lake		1 Sample	
Outlet of Syracuse Lake (for nutrients leaving system) - West Outlet of Lake			1 Sample
- Wawasee near former Oakwood Inn		1 Sample	

* The possibility of the South Shore Golf Club discharge being a point source requiring a National Pollutant Discharge Elimination System (NPDES) permit was examined. There has not been an NPDES permit issued for a point source discharge anywhere in the WAW.

** WACF Ecology Committee and Kosciusko County Health Department took samples and arranged for analytical testing. Commonwealth tabulated and interpreted results.

The following sampling site locations are indicated on the map in Exhibits 2 and 3.

- Site 1 - Dillon Creek North Tributary (Norris Branch, downstream of culvert)
- Site 2 - Dillon Creek Middle Tributary (Launer Ditch, upstream of culvert)
- Site 3 - Dillon Creek South Tributary (Dillon Creek, downstream of culvert)
- Site 4 - Dillon Creek outlet to Lake Wawasee (outlet of Enchanted Hills channels at Hatchery Road Bridge)
- Site 5 - Turkey Creek at Indian Village (public access Site upstream of S. R. 5)
- Site 6 - Turkey Creek inlet to Lake Wawasee (at Hatchery Road Bridge)

1. Parameters to be Sampled

Tributary waters were analyzed for the following parameters to their analytical detection limits:

Table 8
Watershed Sampling Analytical Parameters

Water Quality Parameters	Detection Limits milligrams per liter (mg/l)*
Total Phosphorus (Total P)	0.01
Ortho Phosphorus (Reactive P)	0.01
Ammonia Nitrogen (NH_3 & NH_4 - N)	0.03
Total Kjeldahl Nitrogen (TKN - N)	0.10
Nitrate Nitrogen (NO_2 & NO_3-N)	0.10
Total Suspended Solids (TSS)	4.0
Escherichia coli	N/A

* milligrams per liter (mg/l) = parts per million (ppm)

2. Point Source Discharges in the Watershed

A review of Indiana Department of Environmental Management (IDEM) records show that there are no permitted point source discharges in the Wawasee Area Watershed (WAW). There have been local accounts of episodic discharges of water through the South Shore Country Club Ditch. These accounts claim that water discharged from the ditch is turbid and foaming. If there is a discharge pipe in the ditch it is unpermitted. The IDEM indicated that they would follow up on the local reports of discharges to verify the existence of a discharge pipe. To date this investigation by IDEM has not taken place.

B. Methods and Materials

All watershed grab samples were taken with new, clean sample storage containers, and preserved with ice. All samples were transported to National Environmental Testing Laboratories (which is EPA certified) within prescribed holding times.

All samples were analyzed according to the methods outlined in Standard Methods for the Examination of Water and Wastewater (see references).

Escherichia coli grab samples were preserved and delivered to the lab for analysis within 24 hours.

C. Analytical Results

The following tables present the results of the watershed sampling. The mean of the concentrations of nutrients and total suspended solids are presented as the top number in each table cell and the bottom numbers in parentheses in each table cell represent the range of concentration values of each parameter.

Table 9
Baseflow (Dry Weather) Tributary Water Quality Data - Mean of Values*
Range of Sample Values in Parentheses

Site	Total P mg/l* (Range of Values)	Reactive P mg/l* (Range of Values)	NO_2+NO_3 mg/l* (Range of Values)	TKN-N mg/l* (Range of Values)	NH_3+NH_4 mg/l* (Range of Values)	TSS mg/l* (Range of Values)
1	0.06 (0.05-0.08)	0.04 (0.03-0.05)	2.0 (0.7-2.5)	0.45 (0.88-0.95)	0.12 (0.1-0.17)	1.3 (1-4)
2	0.06 (0.05-0.08)	0.04 (0.03-0.05)	6.4 (3.9-8.9)	0.15 (0.1-0.21)	0.12 (0.08-0.16)	2.3 (1-4)
3	0.08 (0.06-0.1)	0.04 (0.03-0.05)	5.1 (2.8-8.3)	0.77 (0.22-1.6)	0.15 (0.08-0.21)	5.7 (1-11)
4	0.07 (0.05-0.1)	0.04 (0.03-0.05)	3.2 (1.8-4.9)	0.89 (0.77-1.0)	0.15 (0.16-0.1)	4.3 (2-6)
5	0.09 (0.06-0.13)	0.04 (0.03-0.05)	1.7 (0.6-2.5)	1.3 (1.1-1.6)	0.22 (0.15-0.28)	3.7 (1-9)
6	0.07 (0.05-0.08)	0.04 (0.03-0.05)	1.6 (0.7-2.5)	0.91 (0.88-0.95)	0.12 (0.1-0.17)	2.0 (1-4)

Table 8 describes water quality parameters analyzed - * Values are in parts per million (mg/l). Sampling dates: 3/17/95, 4/8/95, 5/19/95.

Table 10
Wet Weather Tributary Water Quality Data - Average of Values
Range of Sample Values in Parentheses

Site	Total P mg/l* (Range of Values)	Reactive P mg/l* (Range of Values)	NO_2+NO_3 mg/l* (Range of Values)	TKN-N mg/l* (Range of Values)	NH_3+NH_4 mg/l* (Range of Values)	TSS mg/l* (Range of Values)
1	0.05 (0.05)	0.045 (0.04-0.05)	2.8 (2.8)	0.72 (0.72)	0.15 (0.13-0.17)	3.5 (1-6)
2	0.095 (0.06-0.13)	0.06 (0.04-0.1)	10.8 (8.6-13)	0.19 (0.19)	0.13 (0.1-0.17)	11.8 (1-24.5)
3	0.09 (0.05-0.14)	0.06 (0.04-0.1)	9.6 (3.7-17)	0.15 (0.1-0.2)	0.13 (0.1-0.17)	12.3 (1-25)
4	0.09 (0.05-0.14)	0.06 (0.04-0.09)	5.4 (2.4-7.3)	0.52 (0.32-0.81)	0.23 (0.15-0.36)	8.1 (1-23.5)
5	0.07 (0.05-0.08)	0.046 (0.04-0.05)	2 (1.5-2.4)	1.14 (0.98-1.3)	0.17 (0.12-0.23)	9.0 (1-20)
6	0.07 (0.05-0.08)	0.04 (0.04-0.07)	2.9 (2-4.5)	1.0 (0.88-1.2)	0.13 (.1-.19)	5.7 (1-11)

Table 8 describes the water quality parameters analyzed. * Values are in parts per million (mg/l). Sampling dates: 3/20/95, 4/21/95, 6/27/95.

1. Additional Sampling Sites (Beyond the Agreed Scope of Work)

Nine (9) additional sites were also monitored during the study. Sites 7 through 15 below were selected to provide more comprehensive data coverage for watershed nutrient and sediment inputs from more localized areas and to determine an estimate of nutrients leaving Lakes Wawasee and Syracuse. The additional sampling sites were not all sampled on the same occasions. From 1 to 5 different samples were taken from each of the additional sites at the discretion of the biologist performing the sampling. Some were wet weather flows and some were base flow events. Therefore, only composite mean concentrations of pollutants are presented from each of these additional sampling sites. Further statistical analysis cannot be performed on these results due to differing sample numbers. These additional nine (9) sites are also located on Exhibits 2 and 3. Following is the list of additional sampling locations:

Site 7 - Ditch draining the South Shore Golf Course (at S.R. 13 culvert)
Site 8 - Papakeechie Lake inlet to Lake Wawasee (downstream of dam)
Site 9 - Bonar Lake inlet to Lake Wawasee (at North Shore Drive culvert)
Site 10 - Ditch at DNR Family Fishing Area from Papakeechie (in family fishing area)
Site 11 - Inlet to Papakeechie Lake (South end of lake, draining from Spear Lake)
Site 12 - Parking lot runoff at DNR Family Fishing Area (ditch in northeast side of Family Fishing Area)
Site 13 - Ditch at Marineland Gardens (downstream end of culvert)

Site 14 - Channel from Lake Wawasee to Syracuse Lake (at Channel Marker Restaurant)

Site 15 - Turkey Creek at Syracuse Lake outlet (downstream of dam, Crosson Park)

Table 11
Water Quality Data from Additional Sampling Sites - Mean of 1 or More Data Points

Site	Total P mg/l	Reactive P mg/l	NO_2+NO_3 mg/l	TKN-N mg/l	NH_3+NH_4 mg/l	TSS mg/l
7	0.12	0.09	6.9	0.65	0.17	64
8	<0.03	<0.03	<0.1	0.83	0.13	1.0
9	0.21	<0.03	<0.1	1.5	0.12	3.0
10	0.27	0.18	<0.1	3.5	2.9	
11	<0.03	<0.03	0.32	0.97	0.15	3.0
12	0.07	0.07	0.45		0.25	
13		<0.03			0.12	7.0
14	<0.03	<0.03	<0.1	0.65	0.14	2.5
15	<0.03	<0.03	<0.1		<0.10	1.0

Table 8 describes the water quality parameters analyzed. Values are in parts per million (mg/l).

D. Discussion of Results

1. The following observations can be made from the data from sampling results from sites 1 through 6:

   a. Nutrient and suspended solids concentrations in Lake Wawasee tributaries are generally higher during wet weather than during baseflow conditions. The difference is small, however (usually less than double).

   b. Site 3 (Dillon Creek South Tributary) usually has the highest nutrient and suspended solids concentrations of any measured sites. Therefore, land treatment should initially focus on this subwatershed, for a greater water quality return for expended resources and effort.

   c. Compared to other small streams draining agricultural areas in Indiana, all of these tributaries have very low suspended solids and phosphorus concentrations (see the attached graphs - Figures 3 and 4). Data from other Indiana Streams was obtained from Indiana Department of Environmental Management, 1991. Indiana Water Quality, 1990, Monitoring Station Records - Rivers and

Streams, Office of Water Management, Indianapolis, IN. A composite average of the following monitoring stations: WR 348, WB 452, EC 27, MC 35, MS 99, PC 21, and S 71.

d. Nitrogen concentrations (especially as nitrate) are unusually high in Dillon Creek Middle and South tributaries, as compared to other small agricultural streams in Indiana (see the attached graph - Figure 5).

2. The following observations can be made from these data from the additional sampling sites 7 - 15.

a. Nutrient concentrations are especially high at Site 10, a ditch draining into Lake Wawasee adjacent to the DNR boat ramp on the south side of the Lake. High TKN and ammonia components indicate that this water may contain septic tank leachate likely from residential sources. Further investigation should be authorized to determine if septic leachate is indeed the source of this pollution, and where it is coming from.

b. Suspended solids concentrations were generally low in all samples except from Site 7, South Shore Ditch draining the portions of the South Shore Golf Course as well as areas west of the golf course. The average TSS concentration at this site was ten times higher than any other site, and an individual sample taken during a heavy rain had a maximum value of 182 mg/l. Runoff from upstream subdivision construction was probably responsible for this high solids loading. Best management practices (BMPs) for construction sites should be installed.

c. The total phosphorus concentration from the wetland runoff between Bonar Lake and Lake Wawasee was somewhat elevated, but the proportion of "reactive" phosphorus readily available as a nutrient was low. This water is "stained" a light brown color from humic acid, typical of many wetland bogs, which may contain relatively high concentrations of nutrients from decaying vegetation but whose nutrients are often bound-up in biologically unavailable forms. Therefore, this does not appear to be a significant source of nutrient loading.

d. Sample site 15, at the outlet of Turkey Creek (Syracuse Lake) Dam shows that most nutrients are staying in the lakes system, at least during the growing season. This is typical during the growing season. It would be expected that the concentrations of nutrients leaving the lakes systems in the outflow over the dam increase in the winter when nutrients are released from decaying plant material.

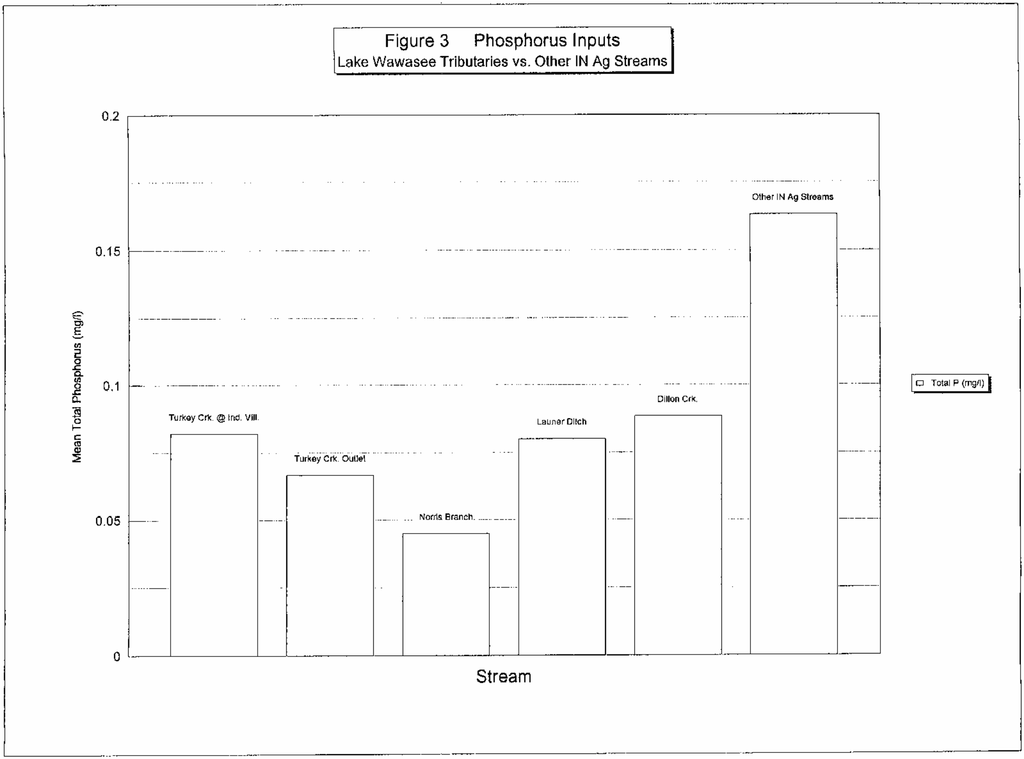


Figure 3 Phosphorus Inputs
Lake Wawasee Tributaries vs. Other IN Ag Streams
0.2
0.15
0.1
0.05
0
Mean Total Phosphorus (mg/l)
Turkey Crk. @ Ind. Vill.
Turkey Crk. Outlet
Norris Branch.
Launer Ditch
Dillon Crk.
Other IN Ag Streams
Stream
Total P (mg/l)

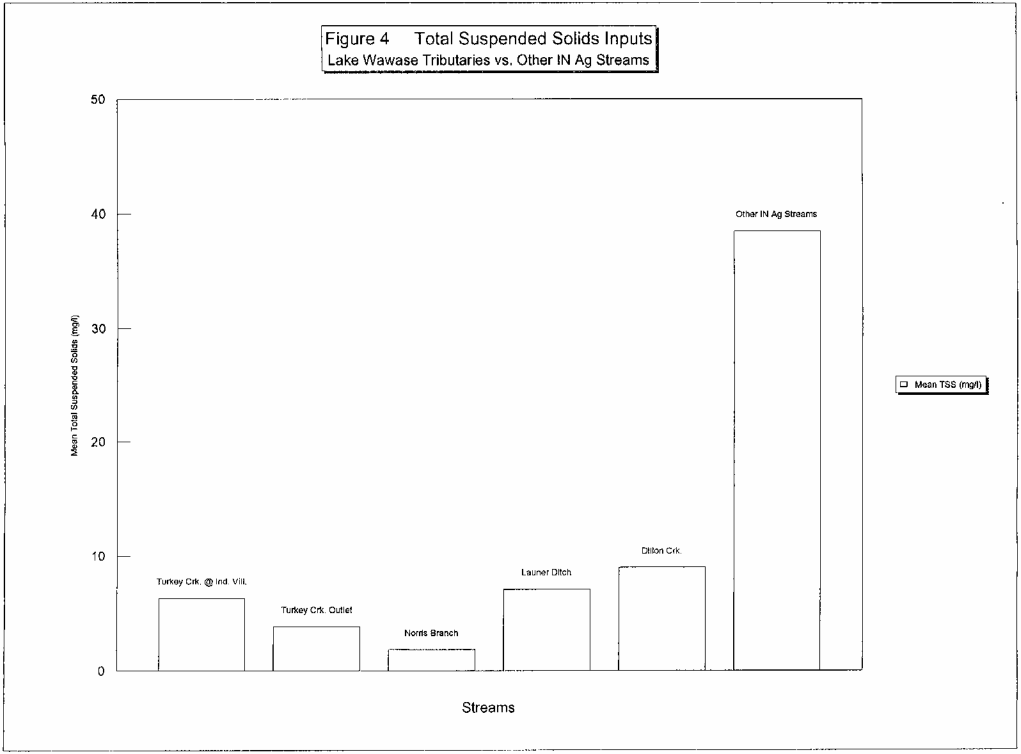


Figure 4 Total Suspended Solids Inputs
Lake Wawase Tributaries vs. Other IN Ag Streams
Mean Total Suspended Solids (mg/l)
50
40
30
20
10
0
Turkey Crk. @ Ind. Vill.
Turkey Crk. Outlet
Norris Branch
Launer Ditch
Dillon Crk.
Other IN Ag Streams
Mean TSS (mg/l)
Streams

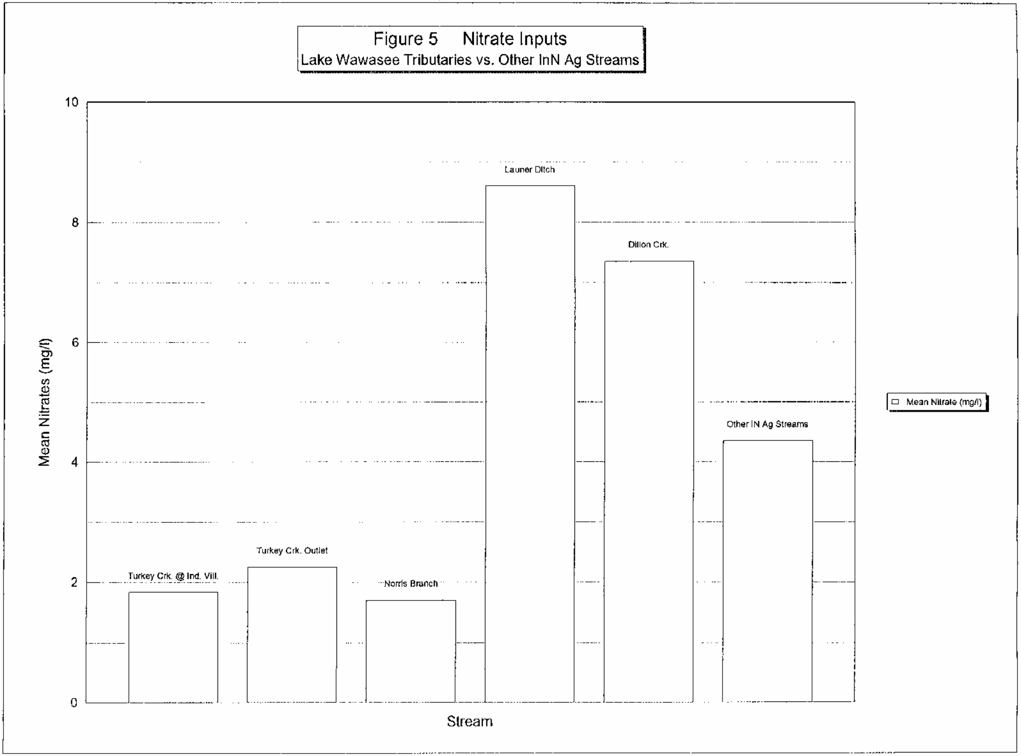


Figure 5 Nitrate Inputs
Lake Wawasee Tributaries vs. Other InN Ag Streams
10
8
6
4
2
0
Mean Nitrates (mg/l)
Launer Ditch
Dillon Crk.
Other IN Ag Streams
Turkey Crk. Outlet
Turkey Crk. @ Ind. Vill.
Norris Branch
Mean Nitrate (mg/l)
Stream

3. External Nutrient and Sediment Annual Loading Calculations

To determine a nutrient and sediment loading budget for Lake Wawasee and to determine which loading sources are most important, loading estimates were made based on average concentrations and flows from each source. Measurements of nutrients in local runoff and direct precipitation were not made during this study. However, an estimate of nutrient transport from local (lake margin) runoff and direct precipitation was modeled. Estimates of loadings from these sources were derived using published models based on average values found in studies of other natural lakes across the United States. The Sonzogni, 1980 model, which was used to estimate local runoff loadings assumes the following average concentrations of nutrients and solids from medium density residential development: P = 0.1 mg/l; N = 1.2 mg/l; TSS = 2 mg/l.

The available data were tabulated for the purpose of prioritizing nonpoint source (NPS) pollution inputs from subwatersheds. The following annual nutrients and solids loading results were obtained from the watershed sampling. Values in parentheses are for Dillon Creek tributaries entering Enchanted Hills. Enchanted Hills outlet was taken at the Hatchery Road bridge.

Table 12
Annual Nutrients and Solids Loading From Tributaries

	Total P kg/yr	Total N kg/yr	Solids kg/yr
Enchanted Hills Outlet	350	22,400	36,000
Norris Branch	(30)	(1,300)	(1,000)
Launer Ditch	(130)	(14,000)	(11,300)
Dillon Creek	(180)	(16,000)	(18,400)
Turkey Creek	810	39,200	46,700
South Shore Ditch	20	1,300	11,300
Papakeechie Watershed	215	3,600	4,000
Bonar Lake Watershed	75	500	1,000
Local Runoff	400	5,000	8,000
Direct Precipitation	155	4,000	1,000
TOTAL	2025 *	76,000	108,000

* This is a maximum estimate. Actual loadings are lower because many of the values used to calculate loadings were set at the analytical detection limit (see Table 8) rather than the actual value below the detection limit. For determining acceptable loading rates (see discussion below), this calculated value was multiplied by 0.75.

E. Summary and Recommendations

During this study, phosphorus and total suspended solids (TSS) were measured in relatively low concentrations. However, nitrate loadings were unusually high. Further study should be done to identify the source of elevated nitrates. Since this type of investigation is typically beyond the functions of the Natural Resource Conservation Service (NRCS), the WACF should have this investigation professionally done. Commonwealth Biomonitoring is available to perform follow-up analyses.

1. Permissible and Excessive Nutrient Loadings

In an attempt to predict how low nutrient loadings must be to prevent lakes from developing nuisance algae and macrophyte growths, scientists have attempted to develop "permissible" and "excessive" loading estimates for lakes of various sizes and depths. The two most common nutrients, phosphorus and nitrogen, have been of highest concern, and the Vollenweider model (1975) has been used most extensively for this purpose in recent years. Vollenweider plotted phosphorus and nitrogen loading vs. mean depth and hydraulic residence time and determined that the clearest lakes had the lowest nutrient loadings and that "permissible" loadings allowed the lakes to stay clear, while "excessive" amounts caused lakes to develop problems. These loadings could be fairly accurately predicted.

Based on the watershed sampling performed in 1995, for Lake Wawasee the total annual phosphorus loading was calculated to be approximately 8% below the level considered permissible in the Vollenweider Model. See Figure 6 for the graphical comparison of Lake Wawasee phosphorus loading data to the Vollenweider Model curves for permissible and acceptable phosphorus loading rates. Most other Indiana lakes are well over the permissible phosphorus loading rates and many of these have phosphorus loadings considered excessive. Lake Wawasee is very unique in the limited amount of phosphorus inputs to the lake. Again, this is evidence of the ability of the wetlands in the watershed to purify water prior to their release to Turkey Creek.

Also based on 1995 watershed sampling, the annual nitrogen loading estimate to Lake Wawasee is approximately 300% higher than the nitrogen loading considered excessive by the Vollenweider Model. See Figure 7 for the graphical comparison of Lake Wawasee nitrogen loading data to the Vollenweider Model curves for permissible and acceptable nitrogen loading rates. Interestingly, the nitrogen loading rate to Lake Wawasee is higher than many other Indiana Lakes. The nitrogen loading is primarily coming from the Enchanted Hills subwatershed which historically had a large wetland area that was dredged and filled to develop the Enchanted Hills subdivision. Presently there are no significant wetlands in this subwatershed to purify incoming water.

Phosphorus is typically the limiting nutrient in freshwater ecosystems. Generally, potassium, carbon, or nitrogen can be added to freshwater without generating a photosynthetic response (algae bloom). However, adding even relatively small quantities of phosphorus to freshwater can result in a photosynthetic response. Based on this study, it cannot be concluded that the nitrogen loading to Lake Wawasee can be the cause of algae blooms. EPA studies in 1973 indicate that phosphorus is limiting in Lake Wawasee. However, the researchers of this study feel that it is very possible that the nitrogen loading can be the cause of algae blooms in Lake Wawasee. Further research would need to be performed to verify if excessive nitrogen loading is indeed causing algae blooms in this system.

Where concentrations of pollutants are below detection limits a commonly used method of estimating acceptable loading rates is to multiply the detection limits by 0.75. The result is the estimated acceptable loading rate of a pollutant.

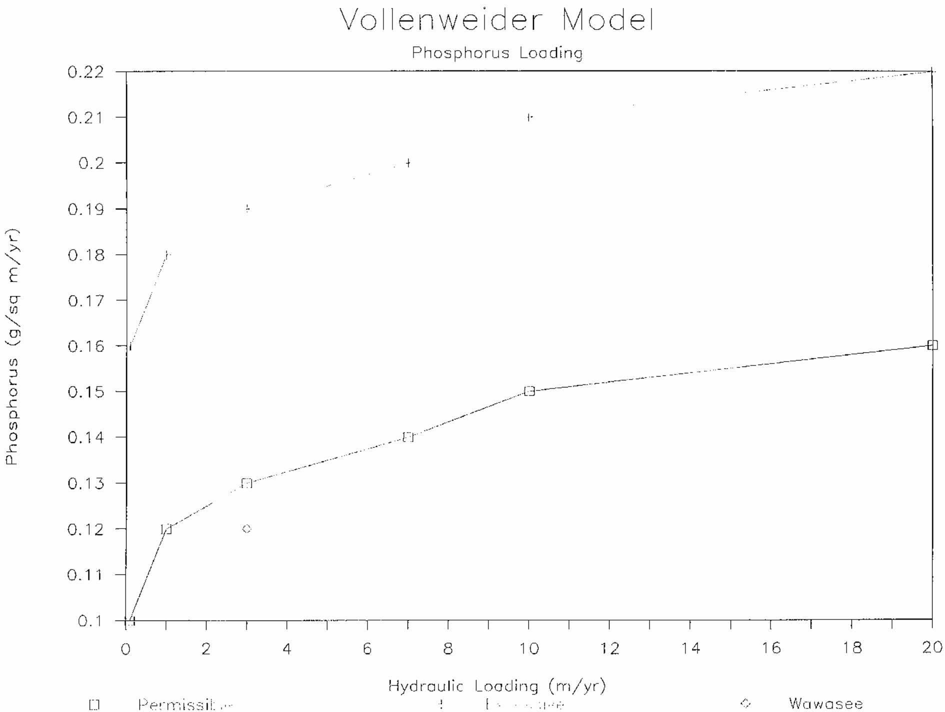

Vollenweider Model
Phosphorus Loading
Phosphorus (g/sq m/yr)
Hydraulic Loading (m/yr)
Wawasee

Figure 6

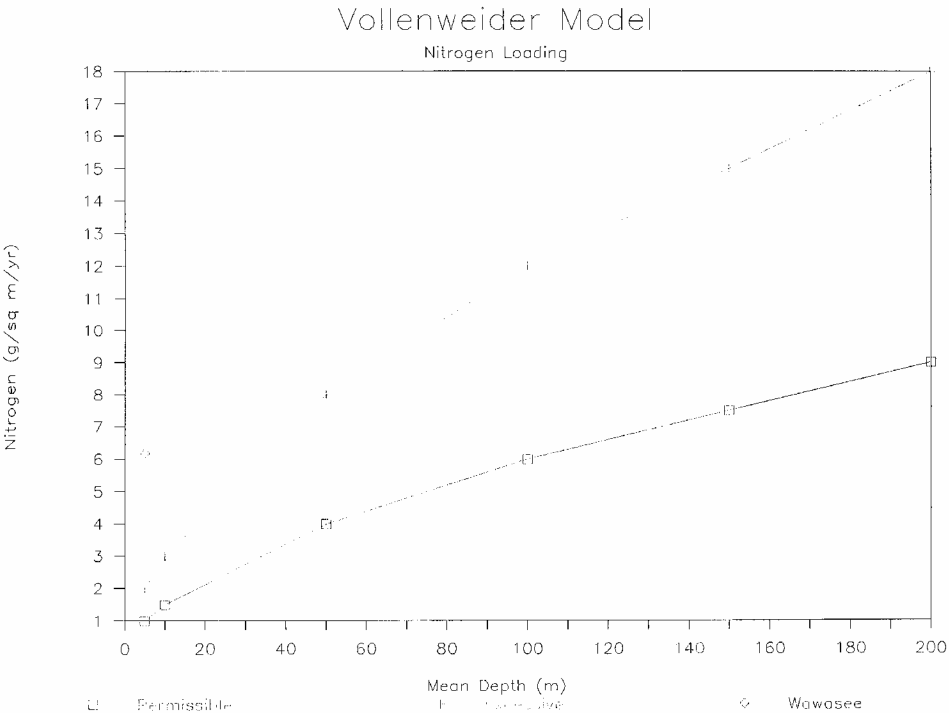

Vollenweider Model
Nitrogen Loading
Nitrogen (g/sq m/yr)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20
40
60
80
100
120
140
160
180
200
Mean Depth (m)
Permissible
Wawasee

Figure 7

2. Prioritization of Loadings

The following Table 13 shows the proportion (or percent of total) of nutrients and solids from each loading source (dimensionless):

Table 13
Proportion of Nutrients and Solids Loading from Tributaries

	Total P	Total N	Solids
Dillon Creek	17%	29%	34%
Turkey Creek	40%	52%	44%
South Shore Ditch	1%	2%	10%
Papakeechie Watershed	11%	5%	4%
Bonar Lake Watershed	4%	<1%	<1%
Local Runoff	20%	7%	8%
Direct Precipitation	7%	5%	<1%
TOTAL	100%	100%	100%

The table above shows that Turkey Creek is the primary source of phosphorus, nitrogen, and sediment loading to Lake Wawasee. This is not surprising, considering that over 40% of the water in the lake originates from this stream. However, when the percent loading of each nutrient and sediment source is divided by its percent flow contribution (based on subwatershed area), a different picture emerges. Using this evaluation technique, values greater than 1 indicate higher than normal loadings, while values less than 1 indicate below normal loadings. Results are shown in Table 14 (dimensionless):

Table 14
Relative Nutrient and Sediment Loading from Tributaries

	Total P	Total N	Solids
Dillon Creek	0.9	1.8	2.1
Turkey Creek	1.0	1.2	1.0
South Shore Ditch	1.0	1.5	7.7
Papakeechie Watershed	0.7	0.3	0.3
Bonar Lake Watershed*	3.1	<1	<1
Local Runoff	1.7	0.6	<1
Direct Precipitation	0.6	0.5	<1

* See Subsection VII, D., 2., c. for an explanation of Bonar Lake results.

The following observations can be made from these data:

a. The Papakeechie Lake Watershed is contributing very low nutrient and sediment loads to Lake Wawasee in relation to its watershed area. This is due to very little of the watershed is being farmed and much of it remains in wetland, especially in the Tri-County F&W Area. Then the Lake Papakeechie ecosystem serves as a treatment system for the water prior to its discharge to Lake Wawasee.

b. The largest watershed, Turkey Creek, contributes to the nutrient and sediment budget of Lake Wawasee almost exactly in proportion to its watershed area. Loadings from this source do not appear to be excessive in comparison to other measured sources.

c. Dillon Creek contributes about twice as much nitrogen and sediment to Lake Wawasee as its watershed area would predict. Sampling results indicate that phosphorus loading from this source, is not excessive (based on the Vollenweider Model). The Enchanted Hills outlet is generally much more turbid than any of its three tributaries but total suspended solids is cumulatively higher in tributaries than at the outlet. This is due to the TSS in tributaries being primarily composed of suspended sediment and the TSS in the channel outlet being composed of algal cells. Sediment is much heavier than algal cells and algal cells decrease the clarity (increase turbidity) more than sediment. In other words, algal cells are lighter than suspended sediments and the particles are larger thereby causing more turbidity in the water column than suspended sediment. That makes the Enchanted Hills outlet much more "turbid" than the tributaries entering the Enchanted Hills channels due to an increase in algal production through the channels.

d. The South Shore Country Club ditch on the west side of Lake Wawasee sometimes carries an extremely high concentration of sediment in relation to its watershed area. Construction on bare land and a lack of erosion control measures around the site is the most likely source. Other local areas of construction around the lake may contribute similar episodic sediment loads.

e. The Bonar Lake subwatershed does have a high concentration of phosphorus in the water relative to the watershed area, however, the phosphorus is in a biologically unavailable form. As is common in wetland ecosystems, the phosphorus is from humic sources.

Section VIII

Discussion of Project Team Aerial Observations

VIII. DISCUSSION OF PROJECT TEAM AERIAL OBSERVATIONS

A. General Aerial Observations by Subwatershed

1. Turkey Creek Subwatershed

The Turkey Creek subwatershed is the largest sub-basin at approximately 9,600 acres or 40% of the total 24,000 acre Wawasee Area Watershed (WAW).

The most notable features of the Turkey Creek subwatershed, observed from flying over, is the quality of the watershed in spite of it being predominantly in agricultural production. Most of the agriculture is on drier upland soils and is in a conservation tillage practice. Between the lakes, ditches and streams of this subwatershed are large areas of low, mature, well vegetated wetlands. The vast wetlands along the Turkey Creek corridor and around the individual lakes on the Turkey Creek chain are the most interesting and prominent feature of this subwatershed.

These wetland areas serve as a buffer to the waterways from transport of nutrients and sediments from agricultural practices. This buffering effect is evident by the results of the watershed water quality sampling. Other Indiana agricultural streams generally contain far higher concentrations of sediments and phosphorus.

There were only a few obvious hotspots visible from the air in the Turkey Creek subwatershed.

a. A cattle feedlot operation allowed cattle access to Turkey Creek on a steep, very eroded slope. Cattle grazing on highly erodible land too close to the waterways is a problem that must be corrected. Fencing animals away from steep slopes and revegetating the slopes will stabilize these areas.

   This can best be implemented by the WACF working cooperatively with the Natural Resources Conservation Service (NRCS) and the landowner to get this work done through a cost share arrangement with the landowner. Some minor reshaping of the slope may be necessary.

b. Most of the dense residential development around Knapp Lake, Harper Lake, and Little Bause Lake are built on soils unsuitable for septic systems to handle wastewater, according to the Noble County Soil Survey. Some of the building sites are on steep soils and other sites are on very low soils with high groundwater tables adjacent to the lakes. Portions of this area appear to have been built on filled wetlands. Water quality within these lakes should be investigated in a similar fashion to the in-lake water quality sampling done for Wawasee, Syracuse, and Bonar Lake.

c. There were some tilled areas on highly erodible land near the Turkey Creek corridor. These are identified on the Exhibit 6, Watershed Hotspots Map.

d. Several fields were in need of grassed waterways. Eroded low areas in fields could be seen from the air even in July.

General Notes

Harper Lake is at the upper end of the Wawasee Area Watershed. It is unique, but has problems of its own. There is unsewered development all around the lake margins. Harper Lake appears to be a major well, with very clear water flowing out of the channel between Harper and Knapp Lake. There is relatively little surface inflow to Harper Lake and it has thick stands of submergent macrophytes. There is an R.V. campground on Harper Lake apparently not connected to a sewer system (an on-site septic tank and/or leach field may be present). The Cromwell treatment plant is approximately five miles from this community. However, sending wastewater to the Cromwell plant may not be feasible since it would require an uphill pump for most of the five miles from Harper Lake.

Further investigation should be done to determine the feasibility of collecting and treating wastewater from the Knapp Lake, Little Bause Lake, and Harper Lake area. Commonwealth Engineers has performed dozens of such studies to evaluate the feasibility of a variety of alternative strategies for collecting and treating wastewater from the area.

Once the water flowing from Harper Lake reached Knapp Lake the water turned substantially more turbid. A thorough study of the water quality of Knapp Lake should be done to get a limnological profile on this lake and to diagnose some obvious water quality problems. This can be performed by Commonwealth Biomonitoring as an additional service. The costs to perform this will depend on the level of study involved. This will be addressed in a separate correspondence on additional studies.

The day Commonwealth Staff flew over the watershed, there was a copper sulfate (aquatic herbicide) treatment in progress on Harper Lake. An obvious blue plume of copper sulfate was highly visible from the air on the south shore of Harper Lake to treat submergent macrophytes and algae. There is an IDNR herbicide application permit issued for Harper Lake.

There are large fields of row crops on highly erodible soils and potentially highly erodible soils, adjacent to the wetland corridor which serves as a buffer for Turkey Creek. This wetland corridor for Turkey Creek must be preserved to continue to function as a water quality buffer.

At Gordy Lake, which reportedly has a remnant population of ciscoes, there is HEL along the western unforested portions of the shoreline. This area is a pasture reportedly in Conservation Reserve Program (CRP). The field appeared to be grazed and cut for hay.

Along the northeast shores of Village Lake and Duely Lake there is a small private campground. The campground is not sewered, and it is not known how the wastewater is managed from this campground. Cattle were noted grazing on a hillside with access to the shoreline, next to the campground at Village Lake. The hillside is not overgrazed presently. The slope does, however, drain directly into the lakes. This allows nutrients from manure that are not taken up by vegetation to enter the lakes. Livestock should be excluded from grazing on lake margins.

2. Enchanted Hills Subwatershed

There is a large number of vacant lots in the Enchanted Hills Subdivision. This means construction will likely be continuing in this subwatershed for some time to come. Erosion control should be in place when these sites are under construction.

In Enchanted Hills channels it is obvious from the air that the steep banks have collapsed into the channel. Light brown sediment was visible from the air in localized areas of the channels suggesting previous bank failures within the channels. Prevention of further erosion from the Enchanted Hills area is addressed in the Watershed Management Plan section of this report.

3. Papakeechie Subwatershed

There is a very large auto graveyard, in the Papakeechie watershed. There does not appear to be a ditch or area of concentrated stormwater flow leaving the site.

a. Approximately 5 to 8 gallons of toxic fluids and contaminants are, or were, in each of the automobiles stored at this site. This is a potential threat to the Lake Papakeechie waters. According to Jean Wells, Secretary of the Papakeechie Property Owners Association, to her knowledge there has not been a documented problem associated with a spill or runoff from the salvage yard site. Others claim there have been runoff problems generated from the site. Regardless of past history, the potential for a release exists and the operation should be required, through an environmental enforcement agency, to drain and recycle all fluids from each automobile brought to the facility.

b. The auto salvage yard does appear to be a potential threat to water quality. However, to put the potential threat from this salvage yard into perspective, at least 20 times the number of cars stored in the salvage yard are in use throughout the WAW every day. These cars spew approximately 15 - 20 pounds of carbon into the atmosphere each hour they are operated, spray hydrocarbon pollution on the roads of the watershed, and most leak contaminating fluids everywhere they go. Witness the black stormwater runoff from nearly all urban roads and parking lots after storm events.

Overall this subwatershed is in a very stable condition. Most of the land area is managed by the IDNR Division of Fish and Wildlife in the Tri-County Fish and Wildlife Area. There are extensive wetlands and small lakes that filter water prior to its discharge from this subwatershed and into Lake Papakeechie.

4. Bonar Lake Subwatershed

The Bonar Lake wetland system between Bonar Lake and Lake Wawasee is a vast and highly diverse wetland system. It serves to purify water seeping into Wawasee from the North. According to sampling results phosphorus concentrations of water discharged from this system is relatively high, compared to other inlets to the lakes, yet is in a biologically unavailable form.

The Bonar Lake wetlands are presently a target area for the WACF wetland purchase program. Given the size of this wetland system, its position on the landscape, and diversity this system should be a high priority for preservation.

5. South Shore Country Club Subwatershed

Construction activity in the watershed was generally the most prominent problem visible from the air. In the South Shore subwatershed, there is a subdivision under construction needing erosion and sediment control measures installed. The ditch draining this construction site has had the highest concentration of suspended sediment delivered to Lake Wawasee of all tributaries sampled in the WAW throughout the study period. Prior to the fly over, the source of the heavy TSS concentration was not known. Without flying over, it may have been more difficult to track the source of the sedimentation.

6. Lakeshore Land Use -All Lakes

Construction and residential activity should keep vegetative ground cover maintained to stabilize soils.

There are several areas under construction at any one time around the lake shore by both do-it-yourselfers and professional contractors. All earth moving activities should be contained with sediment controlling best management practices (BMPs) to prevent off site releases of nutrients and associated sediments from construction activities.

7. In Lake Observations - Wawasee

Near the mouth of the Bayshore Subdivision, there are obvious signs of impact of heavy boating use. Prop scars are obvious across the bottom of the lake. This was also observed at the mouth of the Kanata Manayunk channels along the west side of Johnson Bay.

Bigger, heavier, and more powerful boats are more popular than ever before. Their effects are increasingly showing up in the lakes.

Water bulrushes are losing ground, many lakers and biologists believe this may be due (at least in part) to wave energy and turbulence from boating impacts. Without research involving experimentation we can not be certain that the loss of bulrushes is due to boating impacts. Many historical photos document a prevalence of water bulrushes in most of the shallow areas of Lake Wawasee (Buttermilk Point, the Lilly Estate area, etc.). Water bulrushes provide habitat for gamefish, especially northern pike.

To establish a correlation between wave energy and soft stemmed bulrush communities, recommended research projects would partition off shallow areas of Lake Wawasee, that historically had soft stemmed bulrush communities, then make observations on the successive biological communities that become established.

In Johnson Bay, Conklin Bay, and the southeast portion of Syracuse Lake the wetlands obviously need to be protected from skiers skiing up to the edge of the emergent vegetation. The wave energy causes the wetland hummocks to bounce with waves violently, releasing sediments and associated nutrients from the wetland areas. No wake zone buoys are commercially available. The Indiana Department of Natural Resources may be able to install buoys for the WACF.

Protection of wetland areas in the lake itself should be a priority for the WACF and Property Owners Association. Based on our visual observations made during the course of this project, the Johnson Bay, Conklin Bay, Mud Lake, and the southeast portion of Syracuse Lake (also a boating hazard due to stumps and shallow water) are areas functioning as fish nurseries and should be protected as such for a self sustaining fishery.

These major wetland areas should be designated as no wake zones to protect the wetlands. In addition, deeper drafting boats, such as inboard/outboard cruisers, cause considerable disturbance (resuspension of sediments and nutrients) to the lake bottom due to the depth of the prop and the thrust needed to propel heavier hulls. These types of boats should be restricted from water less than five (5) feet deep.

B. General Summary

The most obvious problem watershed wide is erosion and transport of sediment from construction sites. Best management practice controls should be installed for commercial, residential, utility, or any other kind of construction involving earth moving. An enforceable erosion control ordinance should be passed by the county. The Kosciusko County Lakes Council would be the appropriate body to lobby the county commissioners.

Rule 5 is an Indiana state law in effect that is designed to require any construction site over five (5) acres to have an erosion control plan on file with the state (at a local Soil and Water Conservation District office), that minimizes the transport of sediment from disturbed ground. Rule 5 is deficient in that it is sporadically enforced and only applies to developments over five (5) acres. The vast majority of earth disturbing construction sites in the WAW are less than five (5) acres in area and scattered around the watershed.

Livestock operations along Turkey Creek need to be stabilized through a cooperative agreement between landowners and the Natural Resources Conservation Service (NRCS).

To preserve the character and integrity of waterways of the WAW the expansive wetland areas of the watershed as well as the in-lake wetland areas needs to be preserved.

Section IX

In-Lake Water Quality Sampling

IX. IN-LAKE WATER QUALITY SAMPLING

A. Introduction

Sampling and examination of the in-lake water quality was performed to determine the trophic condition of the lakes of the Wawasee Area Watershed (WAW). Direct sampling of nutrient enrichment and identification of phytoplankton (algal) communities tell the investigators the relative condition and health of in-lake conditions.

The in-lake water quality of the following lakes were sampled after they reached summer stratification:

- Lake Wawasee (two separate basins, two separate sampling occasions)*
- Syracuse Lake
- Bonar Lake
- In addition to the above sampling performed by Commonwealth Biomonitoring staff, the Kosciusko County Health Department, in conjunction with the WACF Ecology Committee, also performed comprehensive lake water quality sampling.

* The two basins of Wawasee were each sampled on a Thursday (calm conditions) and on a heavy boating use Sunday July 3rd. The objective of this comparison was to determine if there is a measurable effect between high use periods and calm periods.

1. Parameters to be Sampled

The sampling was conducted according to the Guidelines For Calculation of the Indiana Department of Environmental Management (IDEM) Eutrophication Index. Temperature and Dissolved Oxygen (D.O.) samples were taken at one meter intervals throughout the water column to determine the levels of the epilimnion, metalimnion, and hypolimnion, in each sampling basin.

Water samples were taken from each of the three stratified layers and analyzed for the following parameters:

Parameter	Detection Limits (mg/l)
Secchi disk depth	N/A
Temperature	C^0
pH	N/A
Total Suspended Solids (TSS)	4
Ammonia Nitrogen	0.03
Total Kjeldahl Nitrogen	0.10
Total Nitrate Nitrogen	0.10
Ortho Phosphorus	0.01
Total Phosphorus	0.01

Phytoplankton samples also were obtained from these lakes. These phytoplankton samples were used to calculate the Indiana Department of Environmental Management (IDEM) Trophic Index.

NOTE: Power Boat Effects on Water Quality

The comparison of eutrophic indices of in-lake water quality, as described above, was conducted in the two deepest basins of Lake Wawasee. One eutrophication index profile was measured during a heavy use period and another during a light use period.

2. Sampling Location Maps

The in-lake sampling sites presented on the map in Exhibits 4 and 5 show the sampling locations within lakes Syracuse and Wawasee of both Commonwealth Biomonitoring and Kosciusko County Health Department sampling locations. There is not a Bonar Lake map supplied in this report because there was only one sample location for a eutrophication index profile taken at the deepest location of the lake.

B. Methods and Materials

1. Lake Eutrophication Indices

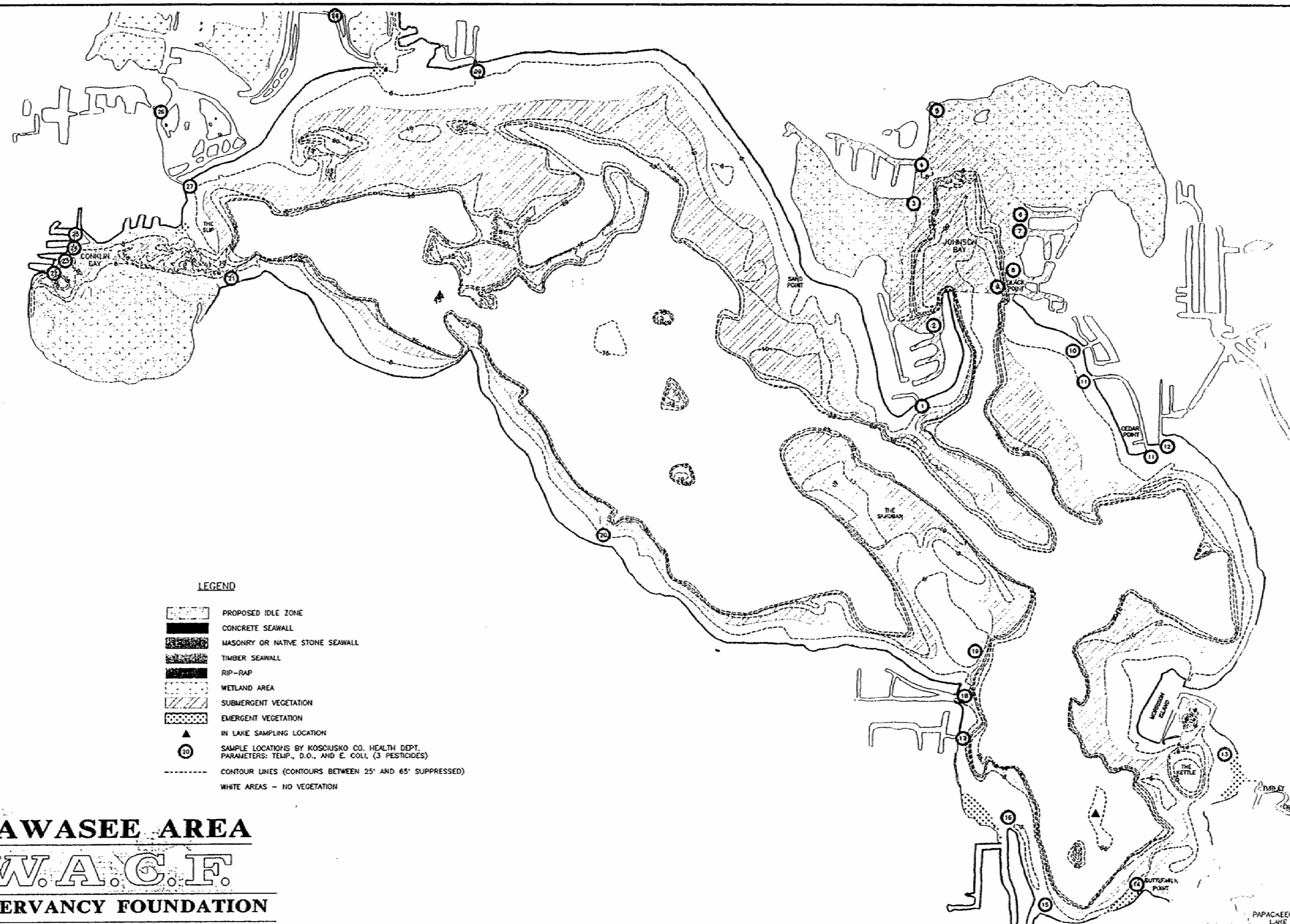
The Indiana Department of Environmental Management uses a unique monitoring technique to determine the "trophic status" of lakes in Indiana. This technique, which has been rigorously tested and proven to produce very reliable results, uses analytical results of the eleven (11) different parameters each taken at two separate depths in a stratified water body (one set of parameters measured in the epilimnion, or upper layer, and the other set of parameters measured in the hypolimnion, or deeper layer). A mathematical function is then used to produce an index value for any given lake based on the results of the analytical sampling. This value ranges between 0 and 75, with lower numbers indicating clear, "high quality" lakes and higher numbers indicating "problem" lakes with nuisance algae problems.

2. Bacterial Sampling of Syracuse Lake Boat Channels Coves

Bacterial sampling by Commonwealth Biomonitoring and the Kosciusko County Health Department were performed in accordance with guidelines in the Standard Methods for the Examination of Water and Wastewater.

3. Other Kosciusko County Health Department Sampling

It is assumed that all parameters sampled and analyzed by the Kosciusko County Health Department Sampling also were done in accordance with Standard Methods for the Examination of Water and Wastewater. A certified lab was used for analytical chemistry.



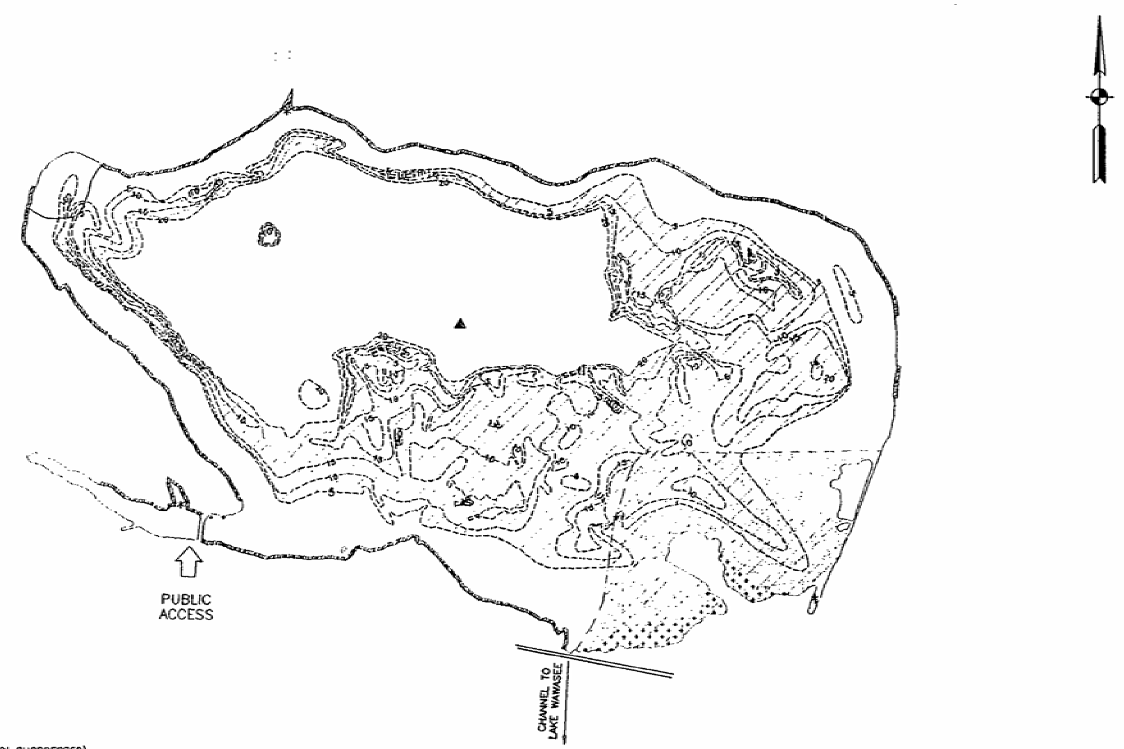
LEGEND

- PROPOSED IDLE ZONE
- CONCRETE SEAWALL
- MASONRY OR NATIVE STONE SEAWALL
- TIMBER SEAWALL
- RIP-RAP
- WETLAND AREA
- SUBMERGENT VEGETATION
- EMERGENT VEGETATION
- ▲ IN LAKE SAMPLING LOCATION
- (20) SAMPLE LOCATIONS BY KOSCIUSKO CO. HEALTH DEPT. PARAMETERS: TEMP., D.O., AND E. COLI, (3 PESTICIDES)
- CONTOUR LINES (CONTOURS BETWEEN 25' AND 65' SUPPRESSED)
- WHITE AREAS – NO VEGETATION

WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION

BY:	COMMONWEALTH ENGINEERS, INC.	DRAWN BY: FN DESIGNED BY: • CHECKED BY: DATE: 8/95 JOB NO: • SCALE: AS NOTED	WAWASEE AREA CONSERVANCY FOUNDATION DIAGNOSTIC / FEASIBILITY STUDY LAKE WAWASEE BATHYMETRIC MAP FEATURING: – SEAWALL TYPES AND LOCATIONS – IN LAKE WATER QUALITY SAMPLING LOCATIONS – IN LAKE VEGETATION MAPPING – PROPOSED IDLE ZONES

EXHIBIT NO. 4



LEGEND

- PROPOSED IDLE ZONE
- CONCRETE SEAWALL
- MASONRY OR NATIVE STONE SEAWALL
- TIMBER SEAWALL
- RIP-RAP
- WETLAND AREA
- SUBMERGENT VEGETATION
- EMERGENT VEGETATION
- ▲ IN LAKE SAMPLING LOCATION
- * BACTERIA SAMPLE LOCATIONS
- -------- CONTOUR LINES (CONTOURS DEEPER THAN 20' SUPPRESSED)
- WHITE AREAS – NO VEGETATION

WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION

BY:	COMMONWEALTH ENGINEERS, INC.	DRAWN BY: FN DESIGNED BY: * CHECKED BY: DATE: 8/95 JOB NO: * SCALE: AS NOTED	WAWASEE AREA CONSERVANCY FOUNDATION DIAGNOSTIC / FEASIBILITY STUDY LAKE SYRACUSE BATHYMETRIC MAP FEATURING: – SEAWALL TYPES AND LOCATIONS – IN LAKE WATER QUALITY SAMPLING LOCATIONS – IN LAKE VEGETATION MAPPING – PROPOSED IDLE ZONES	EXHIBIT NO. 5

C. Analytical Results From Lake Trophic Index Sampling

Commonwealth Biomonitoring staff calculated the IDEM lake eutrophication index for Lakes Wawasee, Syracuse, and Bonar during the summer of 1995 after each lake stratified. The following results were obtained:

Table 15
Lake Wawasee - South Basin
Sampling Date - July 3, 1995

		Value	Eutrophy Points
1	Total Phosphorus (mg/l)	<0.03	0
2	Soluble Phosphorus (mg/l)	<0.02	0
3	Organic Nitrogen (mg/l)	0.66	2
4	Nitrate (mg/l)	0.15	0
5	Ammonia (mg/l)	0.20	0
6	Dissolved Oxygen % Saturation	100	0
7	Dissolved Oxygen % of Water Column >0.1 mg/l	70	1
8	Secchi Disk Depth (Feet)	14	0
9	% Light Transmission at 3 feet	>70%	0
10	Plankton per Liter Epilimnion (x 1000)	143	0
11	Plankton per Liter Metalimnion (x 1000)	717	0
Total Eutrophy Points			3
Lake Classification			ONE

Table 16
Lake Wawasee - North Basin
Sampling Date - July 3, 1995

	Value	Eutrophy Points
1 Total Phosphorus (mg/l)	<0.03	0
2 Soluble Phosphorus (mg/l)	<0.03	0
3 Organic Nitrogen (mg/l)	0.65	2
4 Nitrate (mg/l)	0.15	0
5 Ammonia (mg/l)	0.15	0
6 Dissolved Oxygen % Saturation	100	0
7 Dissolved Oxygen % of Water Column >0.1 mg/l	>70%	0
8 Secchi Disk Depth (Feet)	15	0
9 % Light Transmission at 3 feet	80%	0
10 Plankton per Liter Epilimnion (x 1000)	164	0
11 Plankton per Liter Metalimnion (x 1000)	653	0
Total Eutrophy Points		2
Lake Classification		ONE

Table 17
Lake Wawasee - South Basin
Sampling Date - July 21, 1995

	Value	Eutrophy Points
1 Total Phosphorus	0.04	2
2 Soluble Phosphorus	<0.02	0
3 Organic Nitrogen	0.6	2
4 Nitrate	<0.1	0

	Value	Eutrophy Points
5 Ammonia	0.15	0
6 Dissolved Oxygen % Saturation	100	0
7 Dissolved Oxygen % of Water Column >0.1 mg/l	43	3
8 Secchi Disk Depth (Feet)	9	0
9 % Light Transmission at 3 feet	70	2
10 Plankton per Liter Epilimnion (x 1000)	440	0
11 Plankton per Liter Metalimnion (x 1000)	1400	1
Total Eutrophy Points		10
Lake Classification		ONE

The following tabular data are results of the Lake Wawasee south basin limnological profile from the July 21,1995 field investigation (units are the same as described in Table 17 above):

Depth (ft.)	D.O.	Temp.(C^0)	TP	Ortho P	TKN	NO_3	NH_3
0	8.5	25.5					
3	8.5	25.5	0.04	0.02	0.7	0.1	0.1
6	8.5	25.5					
9	8.5	25.5					
12	8.5	25.5					
15	8.3	25					
18	7.8	24.5					
21	6.6	23.5					
24	5.2	22					
27	3.5	21					
30	0.3	20					
33	0	18.5					
36	0	18					
39	0	18					
42	0	17					
45	0	16	0.04	0.02	0.84	0.1	0.23
48	0	15					
51	0	14					

Table 18
Lake Wawasee - North Basin
Sampling Date - July 20, 1995

		Value	Eutrophy Points
1	Total Phosphorus	0.06	3
2	Soluble Phosphorus	<0.02	0
3	Organic Nitrogen	0.6	2
4	Nitrate	<0.1	0
5	Ammonia	0.37	1
6	Dissolved Oxygen % Saturation	100	0
7	Dissolved Oxygen % of Water Column >0.1 mg/l	56	2
8	Secchi Disk Depth (Feet)	>7	0
9	% Light Transmission at 3 feet	70	2
10	Plankton per Liter Epilimnion (x 1000)	954	1
11	Plankton per Liter Metalimnion (x 1000)	2000	1
Total Eutrophy Points			12
Lake Classification			ONE

Table 19
Syracuse Lake
Sampling Date - July 20, 1995

		Value	Eutrophy Points
1	Total Phosphorus	0.17	3
2	Soluble Phosphorus	0.11	3
3	Organic Nitrogen	1.1	3

	Value	Eutrophy Points
4 Nitrate	0.1	0
5 Ammonia	0.22	0
6 Dissolved Oxygen % Saturation	100	0
7 Dissolved Oxygen % of Water Column >0.1 mg/l	100	0
8 Secchi Disk Depth	12	0
9 % Light Transmission at 3 feet	80	0
10 Plankton per Liter Epilimnion (x 1000)	307	0
11 Plankton per Liter Metalimnion (x 1000)	1700	1
Total Eutrophy Points		10
Lake Classification		ONE

Table 20
Bonar Lake
Sampling Date - July 3, 1995

	Value	Eutrophy Points
1 Total Phosphorus	0.07	3
2 Soluble Phosphorus	<0.03	0
3 Organic Nitrogen	1.8	3
4 Nitrate	<0.1	0
5 Ammonia	0.13	0
6 Dissolved Oxygen % Saturation	100	0
7 Dissolved Oxygen % of Water Column >0.1 mg/l	80	0

	Value	Eutrophy Points
8 Secchi Disk Depth (Feet)	10.5	0
9 % Light Transmission at 3 feet	75	0
10 Plankton per Liter Epilimnion (x 1000)	190	0
11 Plankton per Liter Metalimnion (x 1000)	653	0
Total Eutrophy Points		6
Lake Classification		ONE

D. Discussion of Results

The results from the 1995 limnological investigations indicate that the water quality of the lower WAW lakes is still among the highest water quality in Indiana. Eutrophication Index (E.I.) values were well below the 25 point threshold between Trophic Class I and II.

1. Long-Term Trends

When similar methods of monitoring water quality are used over a period of years in any given lake, it is possible to observe important trends that can tell whether conditions are improving or deteriorating in the lake. One of the most commonly used methods of measuring water quality is "Secchi Disk Depth." The Secchi disk depth reading is the depth at which a black and white disk lowered into the water column can no longer be seen at the surface. Measurements of Secchi Disk Depth have been made in Lake Wawasee fairly regularly by various government and academic researchers and by volunteers since 1974. A comparison of these measurements over time could help determine whether Lake Wawasee is becoming clearer or more turbid.

A study by Spacie and Loeb (1990) reported on Secchi Disk readings made between 1973 and 1989 in Lake Wawasee during the summer months. More recently, the results from the Indiana Department of Environmental Management (IDEM) Indiana Volunteer Lake Monitoring Program (1993) reported additional Secchi Disk monitoring results for the 1989 to 1993 summer periods. Unreported results for the summers of 1994 and 1995 were also available from monitoring volunteer Robert Hampton (personal communication). A summary of these results is shown below:

Table 21
Secchi Depth Trends

	1973-1989	1989-1993	1994-1995
Average Secchi Depth (Feet)	9.3	10.4	8.2
Standard Deviation	1.25	0.96	1.92
Number of Samples	>12	25	15

When the amount of variability among all sample readings is known (this is expressed as "standard deviation"), it is possible to determine mathematically whether one average is significantly different from another. By applying a statistical test to these results, we observe that the average Secchi Disk Depth during the 1989-93 period was significantly greater (5%) than the value for the previous 1973-89 period. This finding indicates that water clarity improved somewhat during 1989-93. The greatest improvement occurred during the 1990-92 period, when average Secchi Depth was as high as 11.5 feet.

During the most recent two-year period, average lake clarity has decreased once again. The Secchi Disk Depths for 1994-95 were statistically less than they were for 1989-1993 but were not significantly different (5%) from those observed during the earlier 1973-89 monitoring period. These results suggest that the clarity of Lake Wawasee has not changed very much during 20 years, except for a brief period in the early 1990's. It is possible that this temporarily increased clarity was due to the accidental introduction of filter feeding zebra mussels to the lake, which also occurred sometime during the late 1980s to 1990. Weather conditions (amount and intensity of rain, wind, and solar radiation) may have been responsible for a brief increase in Secchi depth in the period from 1989 - 1993.

Another way to assess long-term trends is to compare chemical data collected between two periods. In a study of national trends in lake eutrophication, U.S. EPA (1973) calculated nutrient loadings to Lake Wawasee during the early 1970's. Following is a comparison of EPA's loading estimates as compared to those obtained in this 1995 study:

	P-loading (g/square m/yr)	N-loading (g/square m/yr)
EPA	0.11	8.7
Present Study	0.20*	7.6

* = maximum value based on using the detection limit as a basis for calculation. Actual value is lower, but the true value cannot be calculated.

These data show that phosphorus (P) loadings to Lake Wawasee have increased significantly (5%) during the 22-year sampling interval. However, P loadings are still well within acceptable limits as discussed above. Nitrogen (N) loadings have decreased significantly (5%) in the 22 year sampling interval.

E. Other In-Lake Sampling

1. Toxic Substances

The Indiana Department of Environmental Management (IDEM) collected and analyzed pollutants in lake sediments at three locations in Lake Wawasee in June 1987. All pollutants were at or below "background" levels (concentrations associated with areas relatively unaffected by human activity).

IDEM also collected fish tissue samples from Lake Wawasee in 1987. None of the samples collected indicated that pollutants are accumulating in fish at concentrations approaching FDA Action Levels (the point at which fish consumption advisories are issued).

As of the 1987 IDEM sampling, toxic substances were not an item of concern in the Lake Wawasee area (IDEM, unpublished data). Follow-up testing, especially for Atrazine, is recommended.

2. 1995 Bacterial Sampling (Escherichia coli)

From the Kosciusko County Health Department bacteria sampling results (Wawasee) and Commonwealth Biomonitoring bacteria sampling results (Syracuse), there is no acute problem with elevated levels of fecal coliforms on either Lake Wawasee or Syracuse Lake. The following Table 22 presents the results of the Syracuse Lake bacteria sampling for 1995. Exhibits 4 and 5 shows the locations of the in-lake bacteria samples. Figures 8 and 9 show historical comparisons of bacteria sampling results. Results of the Lake Wawasee bacteria sampling is presented with the other parameters sampled by the Kosciusko County Health Department on Table 23.

Notable site conditions were recorded for general information. No relationship between conditions noted and bacteria concentrations can be implied by just one grab sample per site. However, the presence of waterfowl can have a significant affect on the concentration of bacteria in the water.

Table 22
1995 Syracuse Lake Bacteria Sampling Results

Sampling Site*	Notable Conditions	Cells/100ml
North Shore Channel	Seawalls - Entire Channel	90
South East Channel	No Sea Walls, Shallow Water	40
Channel N. of Public Access	Seawalls and Waterfowl Present	120

* One sample taken per site.

3. Kosciusko County Health Department Wawasee Lake Study

On July 11, 1995, the Kosciusko County Health Department, in conjunction with the WACF Ecology Committee, performed comprehensive water quality sampling throughout Lake Wawasee. The parameters sampled in this study were:

- Depth
- Water Temperature
- Relative Clarity
- Dissolved Oxygen
- Escherichia coli (E. coli)
- NO_2
- Ammonia
- Ortho Phosphate
- Some Pesticides (at sites marked with an * on Table 21)

The sampling sites as depicted on Exhibits 4 and 5 are identified below:

Sampling Site No.	Site Description
1	Channel behind Ogden Island
2	Channel behind Sunset Beach
3	Kanata Manayunk South Channel
4	Kanata Manayunk North Channel
5	Johnson Bay Golf Course Channel
6	Johnson Bay Marina Channel off Smith Drive
7	Johnson Bay channel - 1st south of Marina
8	Johnson Bay channel - 2nd south of Marina
9	Johnson Bay channel - 3rd south of Marina, N. of Black Point
10	1st Channel south of Black Point
11	north of south entrance behind Cedar Point
12	Enchanted Hills outlet
13	Turkey Creek outlet

14	Papakeechie outlet
15	Marineland Garden Channel South
16	Marineland Garden Channel North
Sampling Site No.	Site Description
17	LeeLand Channel South
18	LeeLand Channel North
19	Sandbar (sunken Island)
20	Tuttle Ditch between piers 526 - 527
21	Channel East of Conklin Bay
22	Macy's Channel
23	1st channel north of Macy's
24	2nd Channel north of Macy's
25	Frog Channel
26	Channel coming from west outletting into Main Channel
27	Channel behind Kale Island
28	Channel behind Pickwick (at end of bridge)
29	Channel at Rainey Court
30	Middle of Lake
31	Conklin Bay

Table 23 presents the results of this water quality study. Based on these results, the only elevated levels of bacteria are in the vicinity of the outlet of Turkey Creek and in the channel across from the public access site on Syracuse Lake.

Atrazine was found in detectable concentrations at each location tested for pesticides. Atrazine is commonly found in surface and ground water throughout the cornbelt as Atrazine is among the most widely used pesticide used in corn production. This is a problem that should be followed up with additional monitoring to determine if concentrations are increasing. Since the 1987 IDEM study did not find Atrazine in lake sediments or fish tissue, perhaps these two environmental medias (sediment and fish tissues) should be sampled again to determine if Atrazine is now a problem in Lake Wawasee's environmental media

Atrazine concentrations are above the EPA maximum concentration level (MCL) for potable water (3ug/l). Because Lake Wawasee is not used as a drinking water supply, this should not pose a human health hazard in the short term. This situation should be monitored again in the future.

Table 23
Kosciusko County Health Department Wawasee Lake Study Results

WAWASEE LAKE STUDY

Study done in the morning of July 11, 1995. Temp in the upper 80's, clear and sunny with no recent rain.

Site #	Depth	H_2O Temp	Clarity	DO	E. Coli	NO_2	Ammonia	Ortho Phos	Comments
1	4 ft	14°C	Hazy	10	<10	<0.1	0.1	0.04	
2	3.5 ft	14°C	Hazy	10	<10	<0.01	<0.01	0.03	
3	3 ft	14°C	Clear	10	<10	<0.1	<0.1	0.04	
4	6 ft	14°C	Hazy	10	<10	0.1	<0.1	0.03	
5	6 ft	14°C	Clear	11	<10	0.2	<0.1	<0.03	*Pesticide sample taken. Below detection limits for all tested for except Atrazine=0.68.
6	4 ft	14°C	Hazy	11	<10	<0.1	<0.1	0.03	
7	4 ft	14°C	Clear	12	<10	<0.1	<0.1	0.04	Five ducks on seawall about 60 ft away.
8	?	14°C	Murky	10	<10	0.2	<0.1	0.03	Ducks on grass two houses away.
9	3 ft	14°C	Hazy	10	<10	<0.1	<0.1	0.04	
10	6 ft	14°C	Murky	10	<10	0.2	<0.1	0.03	
11	4 ft	14°C	Clear	11	<10	0.2	<0.1	0.03	Ducks close by in water.
12	5 ft	13°C	Murky	14	<10	3.0	<0.1	0.04	Ducks on shore.
13	2 ft	12°C	Clear	7.5	150	1.0	<0.1	0.04	Inlet.
14	1 ft	16°C	Clear	12	<10	0.1	<0.1	0.08	Inlet. Geese close by.
15	3 ft	15°C	Murky	11	<10	0.1	<0.1	0.03	
16	?	14°C	Hazy	16	<10	0.2	<0.1	0.05	
17	?	14°C	Murky	15	10	0.5	<0.1	0.04	
18	?	14°C	Hazy	11	<10	<0.1	<0.1	0.03	

Table 23 (continued)
Kosciusko County Health Department Wawasee Lake Study Results

Site #	Depth	H^2O Temp	Clarity	DO	E. Coli	NO_2	Ammonia	Ortho Phos	Comments
19	3 ft	14°C	Clear	13	<10	0.1	<0.1	<0.03	Boats and people around.
20	3 ft	14°C	Clear	11	30	0.6	<0.1	0.04	*Pesticide sample taken. Below detection limits for all tested for except Atrazine=0.87.
21	4 ft	12°C	Clear	12	<10	<0.1	<0.1	<0.03	
22	5 ft	12°C	Cloudy	9.5	10	<0.1	<0.1	0.03	
23	4 ft	12°C	Clear	9	30	<0.1	<0.1	0.04	
24	3 ft	12°C	Clear	8.5	20	<0.1	<0.1	0.04	
25	4 ft	12°C	Hazy	7.5	<10	<0.1	<0.1	0.04	
26	3 ft	13°C	Hazy	8	<10	<0.1	<0.1	0.03	*Pesticide sample taken. Below detection limits for all tested for except Atrazine=0.44.
27	3 ft	12°C	Clear	8	30	<0.1	<0.1	<0.03	
28	3 ft	10°C	Hazy	10	<10	<0.1	<0.1	0.04	
29	3.5 ft	14°C	Hazy	9.5	<10	<0.1	<0.1	0.04	
Middle	?	14°C	Hazy	11	<10	0.1	0.1	<0.03	
Conklin Bay	5 ft	6°C	Clear	13	-	-	-	-	*Pesticide sample taken. Below detection limits for all tested for except Atrazine=0.54.

DO or dissolved oxygen levels are considered good at levels of 10 or higher. E.Coli numbers above 235 may be grounds for closing a public beach. Animal or human waste affect E. Coli levels.
* Pesticides tested for were Alachlor, Atrazine, and Organochlorine Pesticides.

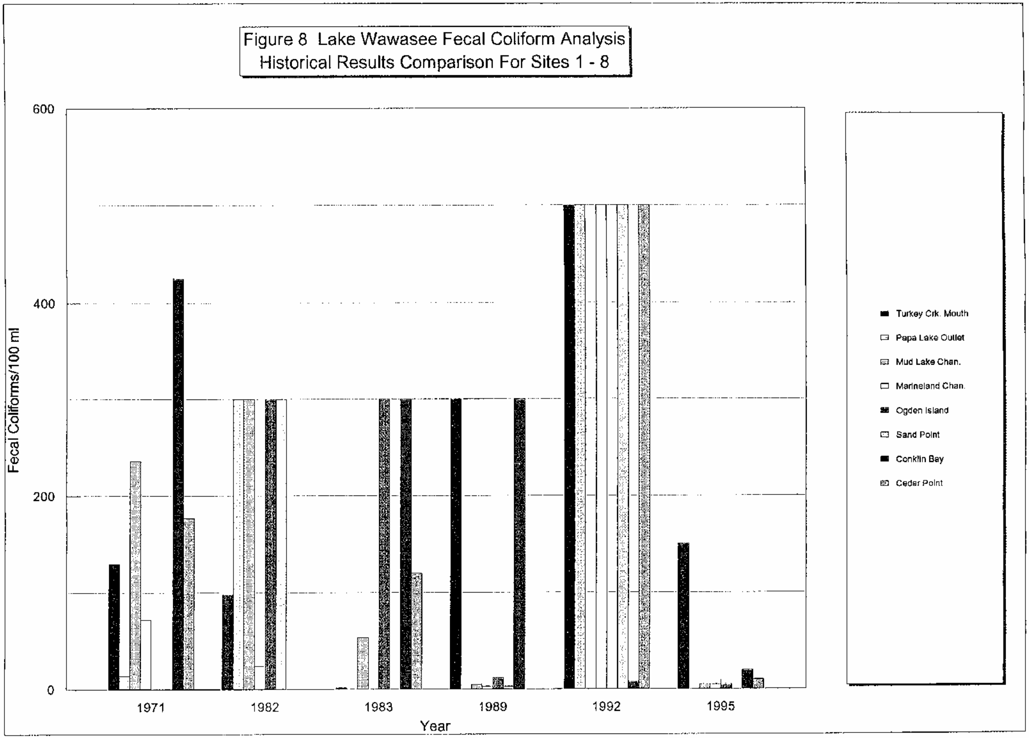


Figure 8 Lake Wawasee Fecal Coliform Analysis
Historical Results Comparison For Sites 1 - 8
Fecal Coliforms/100 ml
600
400
200
0
1971
1982
1983
1989
1992
1995
Year
Turkey Crk. Mouth
Papa Lake Outlet
Mud Lake Chan.
Marineland Chan.
Ogden Island
Sand Point
Conklin Bay
Cedar Point

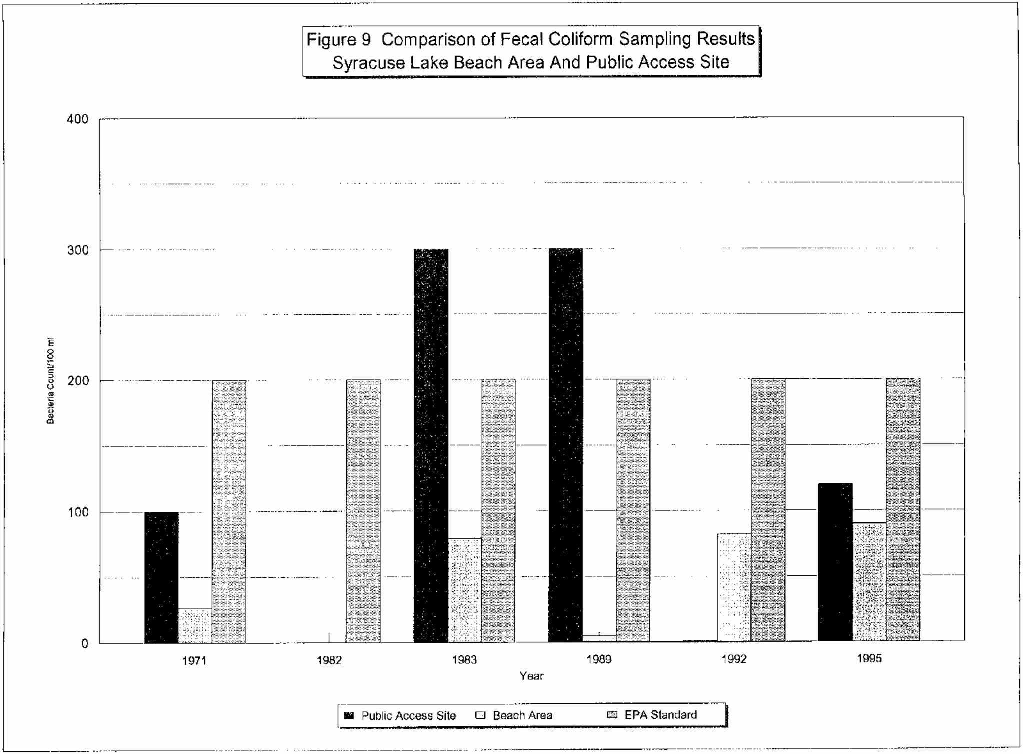


Figure 9 Comparison of Fecal Coliform Sampling Results
Syracuse Lake Beach Area And Public Access Site
400
300
200
100
0
Bacteria Count/100 ml
1971
1982
1983
1989
1992
1995
Year
Public Access Site
Beach Area
EPA Standard

F. Summary and Recommendations

Both in-lake sampling results and the watershed sampling results, produced consistent analytical results. The Enchanted Hills subwatershed exhibited high nitrate concentrations, and the outlet to the Enchanted Hills channels were consistently murky or turbid.

Bacteria is not a problem in the lake. Concentrations were well below EPA standards for full body contact recreation (235 cells/100 ml of water). However, the source of bacteria near the mouth of Turkey Creek should be investigated further due to consistently high concentrations each time it is sampled. Even the concentrations measured at the mouth of Turkey Creek are well below EPA full body contact standards. The source of bacteria may also be a source of nutrients or sediments to the water column that needs to be corrected (e.g., failing septic systems, or livestock runoff).

Similar to other Indiana water bodies, Atrazine does show up in measurable concentrations above the USEPA maximum concentration limit (MCL = any detectable quantity) for potable water. However, the concentrations are not considered alarming for full body contact recreation. Regardless, it is disturbing to know that Atrazine is increasingly showing up in measurable concentrations in Indiana surface waters.

In-lake phosphorus concentrations are consistently low wherever tested. The source of the high nitrate concentrations in the Enchanted Hills subwatershed should be investigated further. As mentioned before, the elevated levels of bacteria near the mouth of Turkey Creek should be investigated further. There is a potential for concern on the fate of on-board wastewater from boats moored at the marinas around Lake Wawasee, more research needs to be done to determine disposal methods. Commonwealth Biomonitoring scientists are available to perform this sampling, surveying, and investigation.

In-lake water quality of area lakes is holding steady. Testing done on Lake Wawasee and the WAW in 1995 is the most comprehensive set of testing ever done through the IDNR Division of Soil Conservation's Lake and River Enhancement Program on an individual watershed in a given year. A total of one hundred (100) water quality samples were taken (not including the West Noble High School sampling) and analyzed in the WAW in 1995. All results point to the relative high quality of the water in the waterways. This high water quality is a precious and scarce natural resource that should be guarded jealously by the stewards of this high quality watershed.

Section X

General Discussion of Special Problems and Considerations

X. GENERAL DISCUSSION OF SPECIAL PROBLEMS AND CONSIDERATIONS

A. Environmental Effects of Motorized Watercraft in Shallow Water

A recent review of power boat effects on lake water quality (Wright and Wagner, 1991) summarizes potential problems associated with increased boat traffic. One of the most in-depth studies cited in the review was conducted by U.S. EPA at several shallow lakes in Florida. The study concluded that in lakes less than 30 feet deep, a 100 horsepower engine operated for 30 minutes could cause turbidity and nutrient concentrations to increase 2 to 4-fold by resuspending nutrient-rich bottom sediments. Even a 10 horsepower engine could produce significant stirring of bottom sediments. Outboard engines were found to stir-up sediments to the following depths:

10 horsepower	6 feet
28 horsepower	10 feet
50 horsepower	15 feet

The study's findings confirmed what was suspected: the larger the motors used in the lake, the worse the potential effects on lake water quality.

A second in-depth study cited in the review documented the experience of Mohegan Lake in upstate New York. This shallow lake (maximum depth = 15 feet) was nutrient-rich and experienced severe algae blooms. The lake association urged a ban on power boating in the lake. Although power boating was not successfully banned, the amount of boating activity declined as many boaters voluntarily reduced their use of the lake. As power boat use declined, water clarity increased (Secchi depth increased from 2 feet to 5-6 feet). The results from shallow Lake Mohegan cannot be directly extrapolated to the much deeper Lake Wawasee (maximum depth 76 feet and mean depth 22 feet).

There is not complete agreement among scientists about potential harm from power boating on lakes. There is some evidence that boating effects on lake turbidity and nutrient resuspension are short-term and do not cause serious long-term effects on water quality. The potential for harmful effects are probably related to many other variables (substrate type, amount of shoreline development, lake volume to surface area ratio, etc.).

Resuspension of sediments is not an introduction of additional nutrients or sediments to the water column but does allow the resuspended nutrients to be taken up by an algae bloom. An algae bloom from resuspension may not be all bad for lake water quality because resuspended nutrients tied up in algae have an opportunity to be flushed from the lake system resulting in a net loss of nutrients from the system. If the bottom substrate is never disturbed nutrients continue to accumulate over time. Lakes that have a hypolimnion with anoxic (reduced) conditions at or near the bottom, such as Lake Wawasee, typically recycle nutrients anyway through the release of phosphorus formerly adsorbed to bottom sediments in chemically reduced conditions. Since the flushing rate of

Lake Wawasee is only 3.5 years, it is unlikely there would be a significant net loss of nutrients from resuspension of lake bottom nutrients.

Large, heavy, deep drafting boats, such as cabin cruisers, displace large volumes of water and require high thrust to propel. Heavy displacement hulls are the most damaging type of boat to shorelines and the lake bottoms. When under power heavy displacement hulls send a large 3 - 4 foot high wake into the shoreline. Because these boats are deep drafting and require high thrust engines and propellers their resulting turbulence and sediment resuspension reaches deeper and has greater impact to the lake bottom. This researcher has observed cabin cruisers grounding and churning up the lake bottom in several Indiana lakes including Lake Wawasee. Many cabin cruisers also have heads (rest rooms) with holding tanks and grinders capable of releasing wastewater into the lakes. This is illegal under Indiana law. All such valves should be made inoperable by the owner or the marina maintaining the boat while the boat is on an inland body of water.

The IDNR Division of Law Enforcement has the authority to enter and inspect private watercraft to determine if they have mechanisms to release wastewater into inland waterways. According to the IDNR Division of Law Enforcement staff located at the Family Fishing Area office there have been no inspections of vessels because there is no perceived problem at Lake Wawasee.

The impacts of heavy boating use are a concern all across Indiana. Bigger, heavier, and more powerful boats are more popular than ever before. Their effects are beginning to show up more frequently in a variety of ways. For example, among long time Wawasee Area residents there is general agreement that the areal extent of aquatic vegetation as well as the species composition has changed over time, possibly due to wave energy and boating impacts.

In Lake Wawasee, which has a mean depth of only 22 feet and which has up to half its surface area in waters less than 10 feet deep, it would seem prudent to minimize power boating effects on water quality. One potential negative effect of unlimited power boating on Lake Wawasee is the possibility of resuspending bottom sediments from shallow areas that presently host rooted water plants in shallow areas, so that the sediments settle in deeper portions of the lake below the depth of light penetration. Removing all of the fine, organically rich sediment from shallow areas could leave the shallow areas with only infertile, mineral substrates incapable of hosting rooted plants. Eliminating all rooted plant life from shallow areas would be detrimental to the lake because such plants provide cover for fish, help prevent algae blooms, and help keep sediments in place. Some of these plants species are also increasingly rare and deserving of protection (see the section on rare plants and animals). In addition, power boating often causes increased wave action, which in turn creates greater demand by property owners for protective seawalls. Seawall construction can have its own negative effects. Common boating ordinances such as establishing no-wake zones, preventing water skiing in shallow areas, and enforcement of quiet hours (dusk to dawn) should help prevent the most serious impacts from power boating.

The subject of bass boats and early morning bass tournaments is a contentious issue on Lakes Syracuse and Wawasee. While bass boats generally do have large horsepower engines, the boat itself is relatively light and hulls draft from approximately 1 1/2 feet of water at rest to drafting only a few inches on plane. Relatively little thrust is required to propel a modern bass boat. In addition, bass boats are specially rigged for high performance and shallow water use. Engines are mounted very high on the transom, usually on a jack plate device, to raise the prop and lower unit of the engine to be approximately level or even slightly higher than the bottom of the boats. The props of bass boats are designed to be run at a "surfacing" height. In other words, the props are designed to be run with the ears (or tips) breaking the water surface. Therefore, a 14 inch diameter prop set to "surface" on a bass boat is running only about 13 1/2 inches below the water surface. The motor is then trimmed (angled) up so thrust from the motor is pushed up and away from the boat, as opposed to down and away from the boat, to lift the hull further out of the water. Angling the thrust up and away from the boat is evidenced by the "rooster tail" effect coming from behind the engine. This results in very little downward thrust to resuspend lake bottom sediments.

Bass boats are generally safe boats, despite their high speed capabilities, again due to special hull designs. Many bass boat manufacturers design boats to turn tight corners to avoid accidents and to bring the boat to a complete stop within 2 to 4 boat lengths when power is cut from the operator or by the emergency kill switch attached to the operator if the operator is accidentally thrown from the boat.

Most bass boats operators only use the outboard motor for travel a few minutes at a time. After they reach a fishing destination, the small electric motor is used then for several minutes to a few hours for fishing time. Bass boats and tournaments are highly visible lake uses.

1. <u>Measurement of Boating Impact on Water Quality</u>

In an attempt to determine if power boats can affect lake water quality, a simple sampling protocol was developed consisting of conducting one additional limnological profile on the North and South basins of Lake Wawasee on the Fourth of July weekend in addition to a sampling occasion of both basins during a calm period (Thursday) through the week. Both limnological profiles included measuring the "trophic index" value of both Lake Wawasee basins. The first measurements, at two different sites, were made on the Fourth of July weekend (July 3, 1995). This was a three-day weekend, with Saturday July 3rd weather being sunny and hot, preceded by a week of relatively cool, cloudy, and rainy weather. Therefore, algae blooms were minimal at this time. Numerous boats were present on the lake each day of the weekend. However, Monday (July 5th) was cooler and rainy.

A second measurement of the trophic index value of both Lake Wawasee basins was made about two weeks later, on a Thursday and Friday (July 20-21), before the start of a new weekend and after the lake had an opportunity to "settle" from the previous weekend's activity. The period after the holiday weekend was a typical Indiana summer pattern, dry and hot, with intense sunshine and little wind, the type of weather which normally triggers an algae bloom. As expected (by weather conditions), algae blooms were much denser on July 20th and 21st than on July 3rd.

The trophic index value (or Eutrophication Index, E.I. value) of the lake was lower (indicating better conditions) during the heavy-use (Fourth of July) weekend than it was during the later light-use period (average Trophic Index Values of 3 and 11, respectively). The effects from weather patterns and environmental factors (e.g. wind, temperature, cloud cover, sunlight intensity, etc.) preceded these sampling occasions had an overriding effect on trophic index value, which was probably greater than boat traffic effects during this study of Lake Wawasee. One indication of the results of this study is that trophic (or photosynthetic) response to heavy recreational use weekends (introduction of nutrients and/or resuspension of nutrients) is delayed until weather conditions trigger a photosynthetic response.

Algal concentrations in the water column were considerably denser on the July 20 and 21 samplings. This algae bloom could be primary productivity (photosynthesis) in response to phosphorus already in the water column or a photosynthetic response to nutrients introduced into the lake over the holiday weekend triggered by the weather conditions following the holiday weekend. Research to prove which situation prevailed is beyond the scope of this present study, but a follow-up study is recommended.

In a 1971 bacterial study performed by C.E. Gifford on Lake Wawasee, it was determined that bacteria counts at the "Sandbar" fluctuated with recreational use. On weekends when several people were swimming from boats anchored at the Sandbar, the bacteria counts increased substantially. During periods of no use, the bacteria counts decreased to levels consistent with other portions of the lake.

In summary, based on only two lake sampling occasions, there was no conclusive evidence of overall lake water quality impact from boating through this study. There were obvious isolated physical impacts to wetlands with a tremendous volume of power boating within a few dozen feet of wetland hummock areas. Observations were also made of large, deep drafting boats "grounding" in shallow areas of the lake bottom. Further studies can be creatively planned and performed by Commonwealth Biomonitoring to measure boating impacts. Lake Wawasee is a prime candidate as a "study lake" for research applicable state wide.

B. <u>Environmental Effects of Sea Walls</u>

The purpose of a seawall is to protect the shore and upland areas from waves and currents. As well, seawalls also function as a retaining wall for the upland soils and as a bulkhead for docks and mooring boats. In addition, because the seawalls are adjacent to residential property, they also need to be aesthetically pleasing.

The Indiana Department of Natural Resources (Division of Soil Conservation) provided a literature search on seawall construction permits and their effect on lake water quality. We used this information as the basis for our discussion on the environmental effects of seawalls on lake management. Seawalls are sometimes desired by lake side property owners to protect their land from erosion by wave action. However, some types of seawalls can have negative environmental effects. For example, seawalls can cause negative impacts by infringing on fish spawning areas (by replacing natural lake bed and associated vegetation with poured concrete), by impeding flow between the lake and natural wetland areas, by decreasing the "aesthetics" associated with natural areas of lakes, and by increasing wave action in other unprotected areas by wave reflection.

Construction of seawalls is regulated by federal and state laws. Seawalls construction that requires fill in waters of Indiana may require a permit from the U.S. Army Corps of Engineers. The landowner should contact the IDNR Division of Water for permitting direction. Part of this process requires a "water quality certification" from a water pollution agency (e.g. the Indiana Department of Environmental Management for permits in Indiana) to assure the seawall does not adversely impact water quality in its associated water body. Agencies which issue water quality certifications often use the following criteria for such projects:

- Does the project fulfill a need for erosion protection?
  - A site visit may be necessary to determine whether erosion problems are severe.
- Is the material to be used free of pollutants?
  - Materials such as asphalt or other materials that may leach into the water as pollutants are strongly discouraged.
- What type of material is to be used?
  - Concrete is discouraged, due to its forming a barrier to the land water interaction and a disruption in aquatic vegetation growth. Rip-rap using natural field stone is preferred. It is better at breaking up wave energy due to the rounded angles and faces of the stone.
- Is the material to be placed in a wetland area?
  - Filling is seldom allowed or necessary.
- Are there other similar projects on the lake?
  - Projects on unprotected areas between two similar seawalls are often approved.
- Are fish-spawning areas affected?

- Projects near shallows with suitable spawning substrate may not be allowed because increased wave action could interfere with successful spawning.

Some types of bank stabilization are less harmful to the shallow water environment of a lake than others, and some types of seawalls are more efficient at dissipating wave energy. The concrete seawalls around Lake Wawasee, while providing an excellent barrier to shoreline erosion may, in some cases, impede the transport of septic leachate to the lake. However, they are typically some of the most destructive to shoreline habitat and the worst in reflecting wave energy back into the lake.

1. Wave Reflection

Water waves can be either partially or totally deflected or reflected back into a lake from natural or manmade barriers. Reflection of waves implies a reflection of wave energy from the seawall back out into the lake without energy dissipation. A natural, gradually sloping shoreline or beach tends to dissipate energy rather than reflecting it back out into the lake. Similarly, a corrugated vertical surface, such as steel sheet piling, also breaks up wave energy.

With seawalls all around the perimeter of Lakes Syracuse and Wawasee at different angles, these seawalls are simply reflecting waves back into the lake from all angles. This is why Lake Wawasee is such a rough lake (despite wind conditions) with a standing chop that continues to swell long after boat traffic has passed or subsided. Water, being a relatively dense medium, is an excellent conductor of sound and vibration and where wave energy is not broken up, it can continue to bounce off of walls around the lake for long periods.

This excessive turbulence could be a major factor for the disappearance of the soft stemmed water bulrushes. Wave energy generated by boat traffic and wind is sustained in the lake system for relatively long periods of time. This sustained standing chop is due to a lack of shoreline structure capable of physically dissipating or absorbing wave energy. The standing waves eventually wear themselves out due only to the resistance by the water medium. The author recommends the WACF sponsor a study to experiment with energy reduction strategies in shallow water to determine if wave energy is in fact a major factor in the diminished range of the bulrushes. Commonwealth Biomonitoring is available to work with the WACF to develop a study plan and perform the experimentation.

Because natural beaches are excellent dissipators of wave energy and vegetated shoreline is an especially good dissipator of energy, Johnson Bay and Conklin Bay both normally contain water much calmer than the water out in other portions of Lake Wawasee. See Exhibits 4 and 5 for a mapped inventory of seawalls in Lakes Wawasee and Syracuse, respectively.

2. <u>Inventory of Sea Wall Types</u>

   a. Poured concrete seawall
   b. Stacked native rubble and masonry
   c. Rip rap
   d. Timber
   e. Sand beach
   f. Natural shoreline

3. <u>Recommended Types of Sea Wall Construction</u>

While the developed lakeshore is almost entirely covered with sea walls of some type, the most popular design has the inherent design flaw associated with wave reflection. The IDNR Division of Water, issues Lake Permits for shoreline construction and could possibly enforce design standards.

Where seawalls are necessary, in order to minimize wave reflection they should be designed to break up the shape of a wave. The best designs are generally stairstepped slopes or a concave face with a top lip curved back toward the lake to make the wave fall back on itself. See Figure 10 for an example. Generally the seawall will have to be cut back into the landowners property as permitting agencies allow minimal fill in surface waters. Commonwealth is available to design a standard construction detail and write a standard specification for new sea wall construction or seawall replacement. The standard design could be encouraged or enforced by the WACF, the property owners association, or by IDNR on lake permits for new seawalls or reconstruction. Similar to the existing seawalls around the lakes, the design depicted in Figure 10 also requires some fill, anchoring to the bank and some additional cost in curved concrete forming.

A more cost effective, and perhaps aesthetically pleasing seawall is one made from native glacial rubble (large rounded stones), hand placed on a gentle slope. These types of seawalls are very effective at breaking up wave energy and minimizing wave reflection. A good example of a native rubble shoreline can be found in the northeast portion of the main body of Lake Wawasee. There is native stone shoreline, near the Lilly Estate, owned by Dick Tillman, at Pier 786. The water is generally calmer at this location.

Low cost strategies to retrofit wave energy absorption to existing seawalls include:

1. placing piled stone (native rubble with an average diameter of three to twelve inches) in front of the concrete seawalls to break a wave prior to it hitting the seawall, and;

2. installing a biolog, made of coconut fiber or an even longer lasting material called Coair, to the face of the seawall with anchors. Flowering aquatic plants can then be planted in the biolog for aesthetic appeal.

C. Residential and Commercial Lawn Care

Local residential and commercial lawn care has the potential to affect water quality through pesticides and fertilizers applied to area lawns. There is no specific information available on lawn care practices in the Lake Wawasee area, so only a few general observations can be made. The purpose of these observations is to help guide lake residents and operators of commercial property in their decisions about potentially detrimental lawn care practices.

Intensively cultivated turf typically use relatively large amounts of fertilizers during the growing season. In most cases, the fertilizers are from commercial sources originating from sources outside the watershed. Therefore, almost all fertilizers applied to lawns have the potential to add directly or indirectly to the enrichment of adjacent lakes. The amount of enrichment is potentially large. For example, some lawn care experts recommend 2 pounds of nitrogen and 1 pound of phosphorus be applied annually to each 1000 square feet of grass to keep lawns green and healthy. There are roughly 5 million square feet of lawn immediately adjacent to Lake Wawasee, not including golf courses (10 miles of shoreline to a lot depth of 100 feet). If all of these lawns were intensively cultivated according to the recommendations above, the Lake Wawasee watershed could potentially receive 5000 pounds (2300 kg) of additional phosphorus each year from lawn runoff (assuming nutrient uptake into biomass had not occurred). This is more than double the present annual loading estimates (see discussion on nutrient budgets below) and would almost certainly cause rapid eutrophication, with increasingly severe algae blooms and a loss of lake clarity over time. Since these lawns are on saturated organic soils with septic systems, they need little or no fertilizer, regardless many homeowners and commercial property managers have a tendency to over apply fertilizers themselves or pay someone to over apply fertilizer for them.

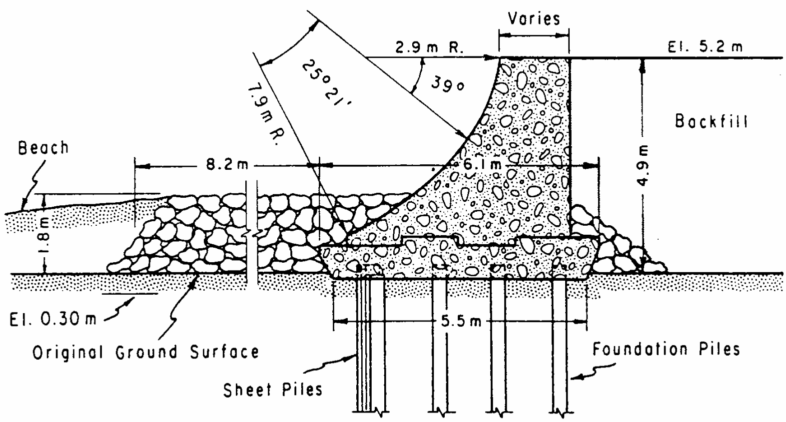
It is important to maintain a relatively dense vegetative ground cover on soil to reduce the rainfall impact and reduce the erosive potential of managed lawns. Whenever possible, lawns surrounding lakes should be fertilized sparingly. Potentially harmful nutrient loading can be drastically reduced if fertilizers derived from local sources (e.g. composted materials originating within the watershed itself) are used for lawn fertilization. On lawns that need nutrient enhancement, the grass clippings from lawn mowing should be left on the lawn for recycling of the nutrients that are in the grass clippings into biomass of new grass leaves, to reduce the net introduction of nutrients into the watershed from outside sources.

1. Household Pesticide Use

Care must be taken in the application of pesticides near a lake or waterway. Contamination can occur unexpectedly. For example, on Skinner Lake in Noble County there is a well documented case of a household insecticide (Dursban) applied for termite treatment to a home by a professional extermination company.
At some point in time after the application, the insecticide migrated through a previously unidentified drain tile near the treated home and discharged to Skinner Lake resulting in a fish kill. After the Dursban contamination a fish consumption advisory was placed on the lake for a period of time.

At the Clear Creek Fish Hatchery in Martinsville (Indiana) in the early 1980's a private farm chemical application contractor applied sprayed pesticide to a field near the hatchery on a windy day. The wind blew enough pesticide into the hatchery ponds to cause a total loss of fish to almost all ninety-two ponds on the hatchery.

While these are two extraordinary cases, even small scale applications of pesticides, especially older pesticides, applied by individual homeowners can be accidentally released to a water body or can be applied where residues can reach a water body. Sprayed herbicides should not be applied on a windy day nor should land applied herbicides be applied with rain in the forecast. In ground applied pesticides should be kept away from all underground drainage conveyances.



COMMONWEALTH ENGINEERS, INC.

FIGURE 10
Concrete Curved-Face Seawall

2. Residential Water Withdrawals for Lawn Care and Washing

Under Indiana law, in accordance with IC 13-2-11.1 and IC 13-2-13 lakes with a legally established average water level (established by a local judge) must be maintained at that level. A lake with a legally established water level can only be lowered for the purpose of shoreline construction, or lake enhancement or restoration projects. Permission for this lowering must be granted by a local court and the Natural Resources Commission. It is unclear as to whether the withdrawal of water for the purposes of residential irrigation or washing is legal. It is definitely illegal if the combined pumping of water results in a lowering of the lake level.

Another caveat of water withdrawal for residential lawn use has to do with return flows. Where flows from boat or car washing or lawn chemical application is allowed to return to a lake the water quality of the lake could be negatively impacted. This type of activity should be discouraged where pollutants may enter the water via overland flow or by entering a downspout, storm drain, or drain tile and flow into a lake.

3. Commercial Water Withdrawals

According to the Indiana Department of Natural Resources (IDNR) Division of Water, there are two registered (permitted) surface water withdrawal facilities in Lake Wawasee. IDNR records for 1991-93 show that the Wawasee Golf and Country Club uses approximately 170,000 to 290,000 gallons of lake water per year for irrigation. The South Shore Golf Course uses an additional 24 to 40 million gallons per year for irrigation. Therefore, from 24,170,000 to 40,290,000 gallons per year are withdrawn from Lake Wawasee for commercial lawn irrigation from these two uses. There is no estimate of the quantity or quality of return flows re-entering Lake Wawasee from this irrigation activity. As mentioned in the water budget section, the total volume of water permitted for irrigation withdrawal is a very small proportion of the total Lake water. However, with the long flushing rate (3.5 years) the withdrawal of water for irrigation could potentially lower the lake levels.

D. Effects of Waterfowl on Water Quality

There is a possibility in some lake systems that an overabundance of waterfowl may contribute to an unacceptable level of nutrient loading from untreated "droppings". A rough calculation was made of potential nutrient loading to Lake Wawasee using the following estimates of waterfowl density and nutrient content:

Waterfowl Density = 0.3 per acre (Webster. 1966)
Waterfowl Body Weight = 5 lb. (Thomas. 1990)
Manure per animal per year = 95 lb. (Thomas. 1990)
% nitrogen = 1.4
% phosphorus = 0.5
Nitrogen Loading per Waterfowl = 1.4 lb/yr
Phosphorus Loading per Waterfowl = 0.5 lb/yr
Total number of resident waterfowl = 1000

Total loading from waterfowl in Lake Wawasee
Nitrogen = 1400 lb/yr (640 kg/yr)
Phosphorus = 500 lb/yr (230 kg/yr)

Based on these estimates and a lake eutrophication model called EUTROMOD, waterfowl in Lake Wawasee could contribute up to 2% of all nitrogen loading and 14% of all phosphorus loading in the lake. This amount of loading is less than that from agricultural runoff, precipitation, and septic tanks. Removing all nutrient loading from waterfowl droppings would have no significant effect on the lake's "Trophic Index" of nutrient enrichment.

Since large flocks of waterfowl resting on the WAW lakes is seasonal, waterfowl concentrations in the Wawasee area are not a significant potential contributor to lake enrichment. However, feeding of waterfowl to attract a larger resident flock should be discouraged.

With the addition of the zebra mussel infestation to Lake Wawasee, it is possible that the waterfowl are functioning to decrease the net nutrient loading to the lake by eating the zebra mussel biomass, then assimilating some the nutrients as waterfowl biomass and depositing some of the other nutrients as waste (manure) outside the water or even the watershed. It was observed during the study period that the waterfowl foraging near docks were picking zebra mussels off the dock structures and ladders. The negative aspects of waterfowl manure nutrient loading is likely offset by the positive aesthetic value of waterfowl and their foraging on zebra mussels.

E. Changes in Aquatic Vegetation with Mapping

No historical information was available to accurately and comprehensively depict the areal extent of former stands of macrophytes in Lake Wawasee. All historical aerial photos examined were either taken in winter, when the vegetation had died back or were taken with a glare on the water surface making it impossible to determine areal extent of macrophytes. There are historical photos (ground level) in possession of lake residents and in historical publications on the lakes area. In addition, Dave Herbst of the IDNR has 8mm home movies of Lake Wawasee which shows some of the emergent bulrushes that were once common around the shallow portions of the lakes.

A general aquatic plant survey was performed to determine the areal extent of aquatic vegetation both emergent and submergent, throughout Lake Wawasee and Syracuse Lake. These areal coverages are mapped on Exhibits 4 and 5. In summary, the macrophyte community of Lakes Syracuse and Wawasee are a very diverse and healthy ecosystem. In fact, this is among the most diverse and healthy macrophyte community, that this researcher has observed on a major Indiana lake system. Native macrophytes dominate the community. The only problem macrophytes noted were stands of spadderdock, curly leaf pondweed, and some coontail, growing in dense clusters adjacent to docks in channels, inhibiting the use to those docks. In the Enchanted Hills channels, there are nuisance stands of milfoil that impede navigation.

F. Management of Wetlands Around the Perimeter of the Lake

Because most of the wetlands around the perimeter of the lakes have been filled in for residential and commercial development, the wetlands that remain are even more valuable. For each acre of wetland lost in the watershed it makes the remaining wetlands even more important to the health of the aquatic systems of the WAW.

The wetlands function as natural purification systems for water entering the lakes. They also function as habitats for diverse species of wildlife. The wetland areas, such as Conklin Bay, Johnson Bay, and Mud Lake, are vital to the health of a self-sustaining fishery. These areas presently function as very rich fish nursery areas. From the observations of researchers on this project, they are very rich in juvenile game fish numbers and species diversity.

These areas should be preserved around the lake for a variety of reasons, including their NPS pollution buffering, habitat value, wave energy buffering, aesthetic and intrinsic values.

The forested wetlands nearest waterways are the highest quality wetlands and should be prioritized for preservation. Forested wetlands are the most efficient at reducing water flow velocities and taking up nutrients for conversion to biomass. Commonwealth Biomonitoring is available to perform an in-depth prioritization and mapping of wetland areas that should be purchased for water quality and habitat preservation. Such a project is outside the scope of this study.

See Exhibit 2 for a map of wetland areas throughout the WAW.

1. Boating Impacts To Wetlands

Protection of lake margin wetland areas in Lakes Wawasee and Syracuse should be a priority for the WACF and the Property Owners Association.

These areas are fish nurseries and should be protected as such for a self sustaining fishery. These wetland systems also serve to purify water coming through them.

Over the course of this project, Commonwealth Biomonitoring staff have seen the lake margin wetland hummocks bouncing up and down violently from wave energy. Since there are no 200 foot marker buoys in place in either Johnson Bay or Conklin Bay or the Southeast corner of Syracuse Lake, people ski right up to the edge of these wetlands.

The Mud Lake area is also a major fish nursery habitat and should be managed as such. It is good management practice to declare certain spawning areas within Mud Lake off limits to boating during the last two weeks of May or the last week of May and the first week of June. This two week closure during the peak of the spawn would allow bass, reportedly the most sought after game fish species, opportunity to spawn in the Mud Lake area relatively undisturbed.

As mentioned in the aerial observations section of this report, there were obvious prop scars around the shallower portions of Lake Wawasee. The prop scars were most obvious at the mouth of the Bayshore Subdivision channels and the mouth of Kanata Manayunk channels in the east side of Johnson Bay.

Among the most obvious plant species that has declined across northern Indiana waters is the softstem water bulrushes. According to historical records, this was a very common plant around Lake Wawasee and Syracuse. They are very important spawning habitat for northern pike. With a diminishing of the soft stem water bulrushes, the northern pike population may have suffered. Northern pike were also formerly abundant according to local historical accounts.

2. Proposed No Wake (Idle Speed) Zones

Presently the only enforceable boat speed restrictions on Lakes Wawasee and Syracuse are in the channels, within 200 feet of the shoreline, and between sunset and sunrise (10 mph).

Most reservoirs in Indiana have as much as 2/3 of their surface areas in idle (no wake) zones. No wake zones are designated for the protection of shorelines and fish habitat and for safety purposes. These speed zones are strictly enforced by the IDNR, Division of Law Enforcement. In Lake Wawasee, the WACF and/or Property Owners Association should consider enforcing a no wake speed zone for Conklin Bay, Johnson Bay and the Mud Lake areas.

In Syracuse there is also a similar fish nursery area and proposed idle zone. This area is also a boating hazard due to stumps and shallow water.

See Exhibits 4 and 5 for illustrations of recommended no wake zones for lakes Syracuse and Wawasee.

The Lake Wawasee/Syracuse Lake Property Owners Association have regulations posted at each public access site. These signs say the lakes are patrolled and the regulations are enforced by the Property Owners Association. The proposed no-wake zones may be able to be passed and enforceable similar to the other regulations listed on the Property Owners Association signs.

If the no wake zones are to be enforceable by the State IDNR Division of Law Enforcement, then a different approach needs to be taken. Any type of a protective zone can be proposed and passed for Indiana water bodies through the Natural Resource Commission through the Administrative Rules process. This is a lengthy process which includes the formation of a study committee, public hearings, a vote for passage by the Natural Resource Commission, approval by the governor, and review and approval by an administrative law judge. If passed, the result is an Administrative Rule, enforceable under an Indiana Administrative Code number the same as a state statute passed by the general assembly.

G. Macrophyte Management in Channels

1. Channel Aquatic Macrophyte Maintenance

Aquatic macrophytes are rooted and floating aquatic plants, commonly referred to as aquatic vegetation or aquatic weeds. There are basically three (3) categories of macrophytes:

a. Emergents, rooted subsurface or free floating plants, with leaves, stems, or flowers emerging above the water surface (cattails, arrowheads, bulrushes, spadderdock);
b. Submergent macrophytes, are plants with the entire plant living underwater (coontail, eelgrass, pondweeds), and;
c. Floating leaved plants, rooted subsurface or free floating with leaves and or stems floating on the water surface (water lilies, lotus).

An overabundance of rooted or free floating macrophytes can be a nuisance to boat and dock owners. However, the vegetation serves to function as critical habitat for many forms of aquatic life including fish.

Many lake residents want their lake to be like a swimming pool and see macrophytes as a nuisance weed that detracts from the beauty of the aquatic environment.

In fact, the existence of macrophytes (particularly emergents), rather than dense algae blooms, are an indication of, as well as an integral part of, a healthy, balanced aquatic ecosystem. Having an abundance of macrophytes in the lake or channel is a far more desirable condition than filamentous algae blooming in place of the macrophytes after a chemical eradication of macrophytes.

There are basically five different physical control methods for removing macrophytes:

1. Dredging to deepen the water below light penetration and levels where photosynthesis can occur;
2. Lake drawdowns to expose root zones to air and freezing temperatures;
3. Chemical herbicide treatment;
4. Mechanical or manual harvesting, and;
5. Biological controls.

Aquatic plant control is generally permitted by the IDNR Division of Fish and Wildlife only in channels around Lake Wawasee and Syracuse Lake where heavy plant growth is an obstruction to boat traffic and/or the plant growth is dominated by exotic species. Studies have been performed by the IDNR Division of Fish and Wildlife that have determined the channels to be critical gamefish spawning areas. The native vegetation of the channels is a valuable component of the lake ecosystem.

2. <u>Sediment Removal for Macrophyte Control</u>

Sediment removal for macrophyte control typically is done to get the depth of the lake bottom deeper than the sunlight can penetrate. Due to the clarity of Lake Wawasee, the channel bottoms would have to be dredged to a depth of over 20 feet deep to get the substrate out of the photic (light penetration) zone and below the maximum depth of macrophyte colonization. Sediment removal is not a feasible solution at Lake Wawasee or Syracuse Lake, because dredging developed channels to such depths would destabilize the shoreline resulting in a bank failure and endangering structures on the shorelines. Very expensive structural measures would have to be installed to prevent this destabilization.

Shallow dredging would remove many of the existing root systems, from which most macrophytes sprout, and would remove the nutrient base from the lake bottom that the macrophytes depend on for growth. Generally the sediments on the surface of the lake substrate are the most nutrient enriched sediments. These are typically the sediments that have been transported into the lake from the watershed. Removal of this layer of sediment generally removes most of the nutrient base from the substrate of natural lakes with a marl or other type of mineral bottom. There are several expensive problems with dredging including dredge spoil disposal and difficult permitting.

3. Water Level Drawdowns

This technique can be used for the aeration and drying of root zones and allowing frost to kill macrophyte root systems. This method of macrophyte control is not a feasible alternative for natural lake systems with a set legal level and\or little opportunity to control the lake level.

4. Chemical Treatment of Macrophytes

According to information supplied by the IDNR Division of Fish and Wildlife, nearly all of the individual "channel associations" around Lake Wawasee have been permitted by the IDNR Division of Fish and Wildlife to apply aquatic herbicides within their respective channels for the control of macrophytes. Syracuse Lake has a one acre area on the south shore near the mouth of the channel to the public access site that has been permitted for treatment of Eurasian milfoil, curly pondweed and algae. Bonar Lakes has a 1/2 acre area that has been permitted for treatment of the same species.

The upper Turkey Creek lakes, including Knapp Lake, Harper Lake, and Little Bause Lake, each have areas from one half to one acre permitted to chemically treat milfoil, curly leaf pondweed, and algae.

While chemical treatments are less labor intensive and can be cost effective in many carefully prescribed situations (especially for exotics), the practice is generally the least cost effective approach for a long term solution to macrophyte management or reduction. This depends on the goal of the treatment. There are cases where chemical treatment has been very cost effective at controlling exotics and allowing restoration of native plant species. As mentioned in the above section, most macrophytes propagate from root shoots or from fragmentation of stems. Some chemical treatments (contact herbicides) do not kill the entire plant, particularly the root system. When roots are left intact they can sprout fresh stems and leaves shortly after treatment. Systemic herbicides (e.g., Sonar, 2-4-D) are designed to kill the entire plant by entering the plant through the root system.

After chemical treatment plants die and decay, leaving the nutrients that were formerly tied up in the macrophyte biomass free in the water column to be taken up by algae or by new macrophyte growth. Generally there is an algae bloom shortly after contact herbicide treatment where the nutrients are assimilated into algal biomass. An algae bloom occurs in the Enchanted Hills channels after contact chemical herbicide (Reward) applications for macrophyte treatment. This is most likely why the water within the Enchanted Hills channels, and the water being discharged from the channels to Lake Wawasee, being more turbid than the water coming into the channels from the watershed. While the researcher's observations of algal blooms after herbicide treatment in the Enchanted Hills channels for this project were not based on empirical evidence, a strong correlation does exist. Assimilation of newly available nutrients may explain why this is the most turbid water on Lake Wawasee.

Another factor contributes to the nutrients available in the Enchanted Hills channels. The soils that the channels were originally dredged in are much richer, organic soils than the less fertile mineral soils that other channels around the lake were dredged in.

Generally herbicide application should only be used in carefully prescribed applications. For a much more comprehensive discussion of chemical macrophyte control see the EPA Lake and Reservoir Restoration Guidance Manual.

5. Macrophyte Harvesting

Manual or mechanical harvesting of macrophytes has many advantages and a few disadvantages. This technique consists of either manually cutting and removing macrophytes with hand tools, or using machinery such as commercial harvesters to mechanically cut and remove macrophyte biomass.

Harvesting is very target specific. Nontarget species or organisms are not substantially affected unless they are entrained into the cutterhead or entangled in the vegetative biomass and loaded onto the barge for removal from the water. Another major advantage is that the plant biomass and all of the associated nutrients and algae that cling to the macrophyte biomass is removed from the water body for disposal. In contrast to herbicide treatments where the biomass is left to die and decay in the water, harvesting with biomass removal actually reduces the net quantity of nutrients in the water column which may be available for primary production (photosynthesis).

Lake Lemon in southern Indiana is a lake that was dominated with milfoil to the point where nearly all types of recreational value was impaired. After over ten years of harvesting macrophytes and removing the biomass from the water the lake is in substantially better condition than it was prior to initiation of the harvesting program. The harvesting has reduced available nutrient concentrations in the water column substantially.

While on a per acre, per treatment basis, harvesting tends to be more expensive, for long term management harvesting is generally an efficient means of macrophyte control in lakes. Several private weed harvesting contractors are in operation in Indiana and are available to give individual homeowners associations quotes on pricing for individual channels. Plant regrowth can be very rapid in the height of the growing season. However, there is not a post treatment waiting period to reenter the water after harvesting.

With some species of submergent vegetation fragmentation of plant stems and subsequent redistribution of the fragments can create infestations within a lake system where they did not exist before. However, with the exception of the Enchanted Hills channels, most of the macrophytes to be harvested from the Wawasee channels are root shoot vegetation rather than the type that grow from plant fragments.

6. Shading and Sediment Covers

This method can sometimes be successful with woven geotextiles. Woven geotextiles or other materials with small pores must be used for the release of gases which are the byproducts of respiration from benthic macro and micro organisms. The material installation is somewhat labor intensive and costs approximately $5.00 per square yard for a relatively long term treatment. The major drawbacks are that the fabric must generally be covered with pea gravel to hold the geofabric to the bottom of the lake. The fabric can be snagged by fishing equipment or propellers, resulting in its being torn or pulled up from the bottom.

7. Biological Controls

Biological controls consist of introducing or stocking animals that graze on the macrophytes. These generally include insect species and grass carp. Insect species capable of significantly grazing macrophytes have been limited to use in warmer climates on warmer climate vegetation. However, recently a lake in Illinois which formerly had a serious milfoil infestation problem, recently had a drastic reduction in the areal extent of milfoil. It was determined that in the few individual milfoil plants remaining milfoil weevils were present. Successive years will prove whether the milfoil weevils are a viable biological treatment option for Midwestern waters.

Grass carp have been a very controversial species of fish in Indiana over the past twenty years. For many years it was illegal to stock grass carp into Indiana waters. Since the development of triploid strains of grass carp, biologically manipulated to be sterile, the IDNR has once again allowed the stocking of grass carp, only in isolated ponds with no connections to other surface waters.

The drawback to grass carp is that they are difficult to control. They will not eat isolated problem weeds such as those in boat channels. They indiscriminately eat weeds all over the lake, including those that are necessary as a nursery to juvenile game fish species or habitat for adult game fish species. Grass carp are an exotic non-native fish which may have other negative impacts to native species of aquatic biota. They are not recommended as a control alternative for the WAW waterways.

H. Periodic Foaming of Lake Surface

Many times a foaming will appear in isolated areas of the lakes, raising pollution concerns among lake users. The foam appears to be a detergent or pollution derivative, however, it is actually a natural phenomena that occurs under certain environmental conditions.

When organic material decays, a solution of tannin and humic acids tends to float to the surface in isolated pockets of the lake or the wind and water currents push the acids to a pocket of the lake. Then the wind proceeds to "whip" or mix the organic solutions into a foam. This is a natural phenomena and does not suggest there is a water pollution problem.

Section XI

Report of Watershed Problem Areas and Presentation of Hotspots

XI. REPORT OF WATERSHED PROBLEM AREAS AND PRESENTATION OF HOTSPOTS

A. Relative Non-Point Source Pollution Potential from Each Sub-Basin

Through extensive water quality sampling; study of aerial photography; watershed reconnaissance via automobile, canoe travel, and a flyover in a small airplane; and from mapping of land use in the watershed, Commonwealth Biomonitoring staff was able to identify several potential and existing non-point source water pollution problem areas throughout the Wawasee Area Watershed (WAW). These have been termed "Hotspots".

Based on the results of watershed water quality sampling and total annual loadings of nutrients and suspended solids to Lake Wawasee from the subwatershed, areas have been prioritized according to the following ranking from highest to lowest priority. Within each subwatershed there is a listing of the hotspots located in that subwatershed, also presented in order of priority from highest to lowest, based on their severity and position in the landscape, which determines the ability of pollutants to reach waterways from each source. The tables below present a prioritization of hotspots within each subwatershed.

Table 24
Turkey Creek Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
29	Southeast Quarter of Section 30, Township 34 North, Range 8 East	Cattle on steep HEL adjacent to and in Turkey Creek.
9	Section 5. Township 33 North, Range 8 East	HEL in field near ditch going to Gordy Lake, possible buffer strips.
7	Section 30, Township 34 North, Range 8 East	Field and pasture erosion in HEL, near Turkey Creek has buffer.
8	Section 30, Township 34 North, Range 8 East	Field erosion near Turkey Creek, not all in HEL, but has forested buffer.
12	Section 32, Township 34 North, Range 8 East	Field erosion in HEL.
18	Section 8, Township 33 North, Range 8 East	Field erosion in HEL.
10	Section 5, Township 33 North, Range 8 East	Field erosion near ditch between Gordy and Hindman, some forested buffer, possible grassed waterway.
17	Section 8, Township 33 North, Range 8 East	Field erosion in HEL near ditch that goes to Hindman Lake

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
16	Section 7, Township 33 North, Range 8 East	Field erosion in HEL near ditch that goes to Hindman Lake, no existing buffer strips.
11	Section 32, Township 34 North, Range 8 East	Field erosion next to ditch going to Rider Lake, no buffer strips.
13	Section 32, Township 34 North, Range 8 East	Field erosion in HEL.
14	Section 28, Township 34 North, Range 8 East	Field erosion near ditch that goes to Rider Lake, possible grassed waterways.
27	Northwest Quarter of Section 34, Township 34 North, Range 8 East	Field erosion near ditch to Knapp Lake.
21	Section 3, Township 33 North, Range 8 East	Field erosion in HEL area, near ditch that goes to Harper, buffer strips.
20	Section 3, Township 33 North, Range 8 East	Field erosion in HEL.
19	Section 4, Township 33 North, Range 8 East	Field erosion in HEL area.
28	Northeast Quarter of Section 10, Southeast Quarter of Section 3, Township 33 North, Range 8 East	Erosion on HEL adjacent to ditch.
22	Section 3, Township 33 North, Range 8 East	Field erosion in HEL area, near Pipe Branch Ditch.
23	Section 2, Township 33 North, Range 8 East	Field erosion in HEL area, near Piper Branch Ditch
6	Section 30, Township 34 North, Range 8 East	Field and pasture erosion in HEL.
25	Section 2, Township 33 North, Range 8 East	Field erosion in HEL.
24	Section 2, Township 33 North, Range 8 East	Field erosion in HEL.
26	Section 11, Township 33 North, Range 8 East	Field erosion in HEL.
15	Section 27, Township 34 North, Range 8 East	Field erosion in HEL, more grassed waterways needed

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
32	Mouth of Turkey Creek in Lake Wawasee	High bacteria counts, needs further study.

Table 25
Enchanted Hills Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
1	Sections 13, 24, & 19, Township 34 North, Range 7 East. General area of Launer Ditch & Dillon Creek	Field rill, gully erosion; channel grading
4	Section 19, Township 34 North, Range 8 East	Field erosion near ditch.
5	Section 20, Township 34 North, Range 8 East	Field rill, gully erosion
General	Enchanted Hills Subdivision	Erosion from bare soil and construction sites. Stabilize channel banks. Maintain healthy ground cover with proper fertilizer applications. Harvest macrophytes r/t herbicide treat.

Table 26
Southside Country Club Subwatershed Hotspots

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
30	Northeast Quarter of Section 20, NPW Subdivision, east of South Shore Country Club	Construction site run-off.
General	Sections 21 & 22. Farm land east of South Shore Country Club	Conservation tillage on fields needed.

Table 27
Other Lakeside Localized Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
32	Section 24, Township 34 North, Range 7 East. Mouth of Turkey Creek	High bacteria counts, possibly from marina or mobile home park. Needs further study.
2	Section 22, Township 34 North, Range 7 East. East of high school	Field erosion in conventional tilled area in HEL.
31	Section 8, Conklin Bay North Point "The Slip" area	Bare construction site contained by seawall.
General	Perimeter of lakes	Construction and lawn care activities must stabilize soils with minimum of fertilizer inputs.

Table 28
On-Lake Use Problems

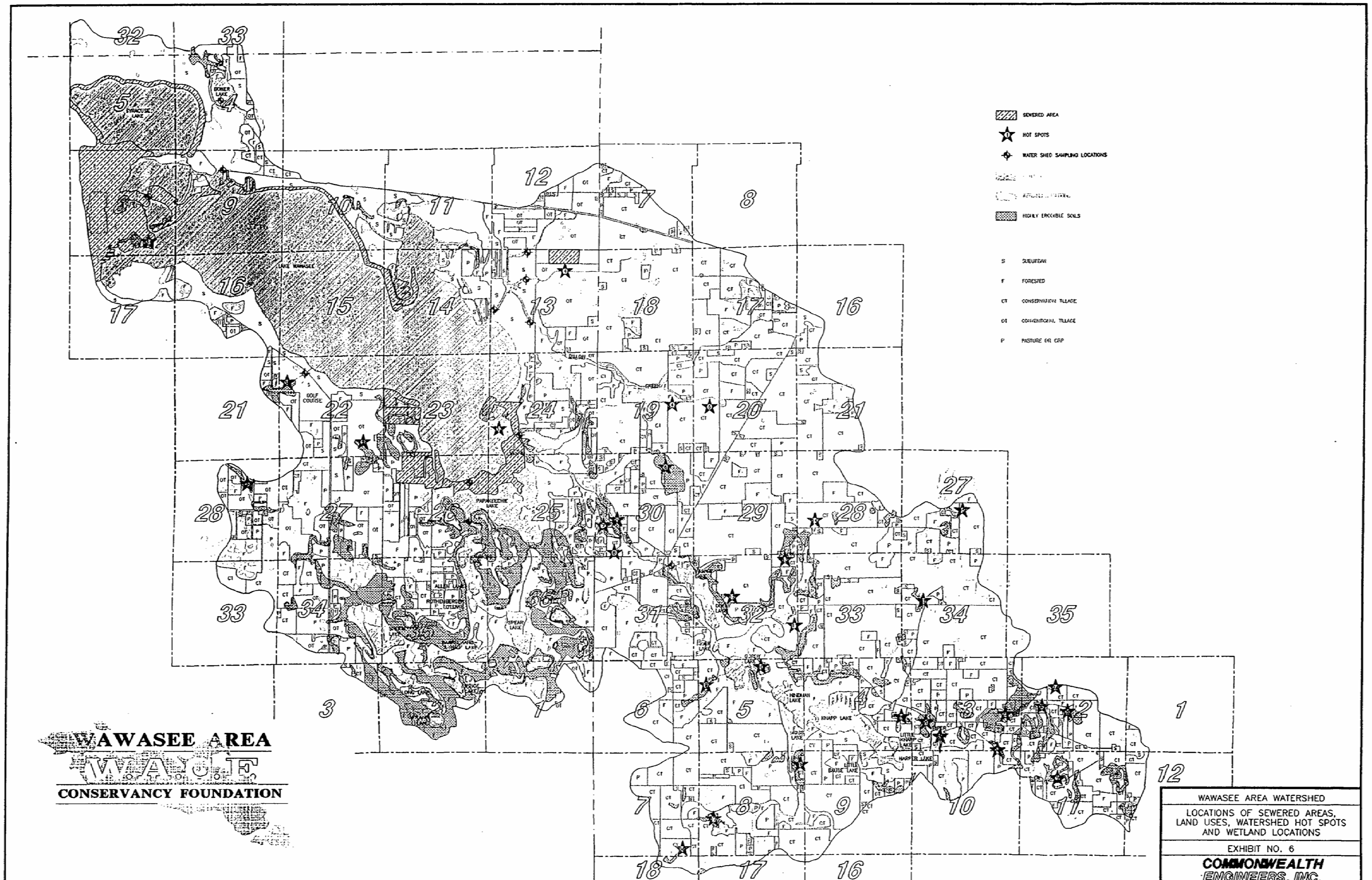
Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	All over lakes	-- Wake in wetlands areas - resuspension -- High speed operation in shallow (<5') areas -- Lack of head pumping facilities -- Lake use etiquette (pollution prevention) -- Advertise public restroom facilities (discourage "going in lakes")

Table 29
Bonar Lake Subwatershed Potential Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	Section 4, Township 34 North, Range 7 East. Lake margins	May need sewers. Further study needed.
General	North of lake	Crop land on HEL.

Table 30
Papakeechie Lake Subwatershed Potential Problems

Hotspot Number	Location (section, township, range, descriptive)	Description of NPS Problem
General	Section 25, Township 34 North, Range 7 East. Papakeechie Road	Auto graveyard. Potential leaching.


SEWERED AREA
HOT SPOTS
WATER SHED SAMPLING LOCATIONS
HIGHLY ERODIBLE SOILS
S SUBURBAN
F FORESTED
CT CONSERVATION TILLAGE
OT CONVENTIONAL TILLAGE
P PASTURE OR CRP
SYRACUSE LAKE
LAKE WAWASEE
GOLF COURSE
PAPAKEECHIE LAKE
SPEAR LAKE
KNAPP LAKE
HARPER LAKE
WAWASEE AREA
W.A.C.F.
CONSERVANCY FOUNDATION
WAWASEE AREA WATERSHED
LOCATIONS OF SEWERED AREAS, LAND USES, WATERSHED HOT SPOTS AND WETLAND LOCATIONS
EXHIBIT NO. 6
COMMONWEALTH ENGINEERS, INC.

Section XII

Evaluation of the Operation of the Dams of Lakes Papakeechie and Syracuse

XII. EVALUATION OF DAM OPERATIONS AT LAKES PAPAKEECHIE AND SYRACUSE

A. Wawasee Area Watershed Dam Operation And Gaging Data

There is a United States Geological Survey (U.S.G.S.) gaging station located at the outlet of Syracuse Lake on Turkey Creek near Crosson Park. This gaging station has been recording flows from the Wawasee Area Watershed (WAW) drainage system since 1943. There are approximately 43.8 total square miles of drainage area upstream of the gaging station. Because there is a control structure (operable dam) to control the flow measured by this gaging station, the gage only monitors lake outflows rather than regional hydrology. Regional hydrology information would be useful for subwatershed studies in the WAW but not necessary given the power of hydrologic models. Gaging stations would have to be installed and operated by the U.S.G.S. for each of the subwatersheds. A formal request to the U.S.G.S. would have to convince the agency to install such gaging stations. There is little likelihood that gaging stations will be installed in the WAW subwatersheds at any time in the near future.

During the past 50 years, the difference between maximum and minimum gauge heights at Syracuse Lake has been only 3.15 feet. The annual rise and fall of lake levels is normally less than 1 foot (Stewart et al., 1993).

1. Discussion of Positive and Negative Aspects of Seasonal Dam Operations

Winter drawdown is generally a good lake management practice for nuisance macrophyte control and to oxidize sediments to create a tighter bond between the sediment associated nutrient molecules and soil particles.

Given the nature of the natural lakes of the WAW and the established legal lake levels which must be maintained, seasonal dam operation is not a feasible alternative for the operators of the Syracuse lake Dam. The operators are flooded with complaint calls in the spring of the year with only minor (.5') fluctuations of the water level. If the operators were to try to manipulate water levels for lake management purposes, the plan would have to be well publicized and supported by property owners.

B. Discussion of General Conditions of Dam Structures and Apparatus

The structure of the Syracuse Lake Dam at Crosson Park is in excellent condition. The existing dam was constructed in 1963 with funds donated by Eli Lilly (along with an operations and maintenance fund established at the same time). The structure is very well maintained and Indiana Department of Natural Resources (IDNR) dam inspection reports give indicate that there is presently no problem with the dam nor has there been since the construction of the existing dam.

1. Syracuse Lake Dam Operators

Matt Vigneault, Syracuse Town Manager, was consulted on the operation of the Syracuse Dam. Mr. Vigneault informed Commonwealth Biomonitoring staff that Mike Brower is the designated operator of the Syracuse Dam. Mr. Brower has been the operator for the past 8 to 9 years. In addition to being the Syracuse Town Manager, Mr. Vigneault is on the Syracuse Dam Board, is the alternate dam operator, and serves on the St. Joseph River Basin Commission. Mr. Vigneault is pleased that there was an interest in the operation of the dam by the WACF.

a. General Background and History

Since European immigrants first came to the Syracuse area and developed settlements, there has been a dam located in approximately the same area as the existing dam in Crosson Park.

The Syracuse Lake legal lake level was set in a 1947 court order from Kosciusko County circuit court. At that time the lake level was legally established at 858 feet above mean sea level. In addition, the Town of Syracuse was designated as the responsible dam operator. The Court order requires the Town of Syracuse to maintain the lake level as close as possible to the legal level of 858 feet. It is unclear as to whether the 1947 establishment of the legal lake level for Syracuse Lake considered the hydraulic relationship between Lakes Syracuse and Wawasee. Never the less, the Lake Wawasee level is controlled by the Syracuse Dam.

b. Syracuse Lake Dam Operations

The Town of Syracuse dam operation staff have tried various strategies to maintain the lake level as stable as possible, including reactionary versus anticipatory strategies to maintain an stable lake level.

As an example of a level maintenance scenario, a 1 inch rain over the watershed takes approximately 4 days to drain into the lakes system. This storm drainage can result in a 3 - 4 inch increase in lake level over the course of 96 hours. Typically, May is the month with the highest rainfall volume, therefore the month requiring the most operator attention. May is also the month that the Town receives the greatest number of complaint calls on the dam operations.

In the past it was recommended that the dam operators take an anticipatory (rather than reactionary) management approach to maintaining the lake level. Based on these recommendations, there have been occasions where the operators have lowered the lakes 1 to 2 inches at the beginning of May to allow room for a storage pool prior to the May rainfalls. In 1990 when this was done, the May rains did not occur and by the end of May the lakes were down approximately 5 to 6 inches. The lakes systems then took a long period to recover to the legal lake level. Since this time, the anticipatory strategy has been abandoned for the reactionary management strategy.

The water must be released from the Syracuse Dam at a controlled rate to prevent causing damage (erosion) to the channel downstream of the Lake and to protect property below the Lake. A minimum amount of flow must be maintained by the dam operator to maintain a stream ecosystem in Turkey Creek below the Syracuse Dam.

The urbanization of portions of the WAW, which has included replacement of wetland and natural pervious soils with impervious rooftops and pavement, has altered the rate of water flow to the lakes and has resulted in the operation of the dam requiring more operator attention to maintain the legal level. Operators of the dam must try to compensate for ever decreasing peak runoff "times of concentration" and the increasing volumes of peak runoff to the lakes system.

Residents of Lake Wawasee routinely call the operators of the Syracuse Dam to complain about the operations of the dam, especially in the heavy rainfall months of spring. Reports from the dam operators show that on the same day a resident of the southeast side of Wawasee called to complain about the lake level being too high and about to flood a yard, while another call from a resident of the west side of the lake complained that the lake is too low and the hull of a boat is hitting the bottom of the lake at their dock.

Since much of the east side of Lake Wawasee was developed on filled wetlands, this area may have experienced some subsidence over the years. At the same time, the person on the west side of the lake may have a boat drafting too deep for his pier. Conjecture aside, the most likely case is that the lake front property owners should learn about the operational constraints at the Syracuse Dam.

c. Recommendation

According to the Syracuse Town Manager, a local judge and the IDNR have recommended that a hydraulic analysis should be done to determine if a new legal lake level should be established to control the Lake Wawasee elevation perhaps independently from, the Lake Syracuse elevation.

Such studies are typically done to determine if there is a better prescribed lake level that would satisfy all of the people who live on Lake Wawasee that call to complain about dam operations in the spring. The drawback would be that to control the water level independently of Syracuse Lake there would have to be a dam constructed in the vicinity of the Main Channel between lakes Wawasee and Syracuse.

2. Papakeechie Dam

The Papakeechie Dam is operated by the Papakeechie Property Owners Association. Ms. Jean Wells is the Secretary of the Papakeechie Property Owners Association (PPOA). Commonwealth Biomonitoring staff have contacted Ms. Wells concerning the operation of the dam. The following report is a summary of the interview with Ms. Wells as well as from field inspection of the dam structure and apparati.

Ms. Wells explained that there is a designated dam operator Mr. Ron Corson (also the president of the PPOA) and two alternate operators (Gary Moore and Ron Curlin). At least one of the dam operators monitors lake levels daily and try to maintain the lake level as close to the same elevation as possible every day.

The Papakeechie Dam is in satisfactory condition. While the east end of the earthen dam appears to be lower, to function as an emergency spillway, there is no evidence of there ever being an overtopping of the earthen dam.

Based on a field inspection by Commonwealth Engineers staff, The outlet structure of the Papakeechie Dam appears to also be in reasonably good operating condition. It consists of a simple stop plank structure with an operable sluice gate as a backup control. From the field inspection, all the working parts appear to be functional.

The sluice gate at the dam is operable and this is how water level is manipulated at the dam. During and after storm events the gate opening is manipulated to prevent the lake from overtopping the emergency spillway. Sluice gate operation is mainly confined to the heavy rains of spring and winter.

The dam structure is in good condition according to IDNR inspection reports. The PPOA is presently saving money for an improvement to the emergency spillway.

Based on the watershed sampling and field reconnaissance, the watershed for Lake Papakeechie is in excellent condition and the water quality coming out of the Papakeechie Dam into Lake Wawasee is very clean.

The watershed upstream of Lake Papakeechie is a water retaining watershed due to the large amount of wetland acres in the watershed. Storm events in this watershed do not have an erosive peak runoff. The runoff from this watershed has relatively low peak flows coming into Lake Papakeechie.

The water of Papakeechie has been examined periodically for zebra mussel invasion. So far zebra mussels have not been introduced to Papakeechie Lake. The PPOA also has water quality sampling done annually to semi-annually. The water testing reports are always good.

Nuisance aquatic macrophytes are harvested (35 acres) and treated chemically with Diquat 2-4-D (200 acres). After herbicide treatment Copper sulfate is used to follow-up as an algicide. This chemical herbicide treatment obviously has no significant impact to Lake Wawasee as evidenced by the dense growth of macrophytes at the mouth of the Papakeechie outlet.

Section XIII

Non-Point Source Pollution Control Alternatives Analysis

XIII. NON-POINT SOURCE POLLUTION CONTROL ALTERNATIVES ANALYSIS

A. Introduction

A collection of the most feasible, widely used, proven structural and non-structural land treatments and non point source (NPS) pollution controls was assembled for consideration to treat hotspots in the Wawasee Area Watershed (WAW). Most of these treatments and materials have been used in other watershed land treatment projects in Indiana.

A watershed land treatment cost spreadsheet, Table 31, was developed to perform a cost analysis of feasible NPS control alternatives that have proven effective in other erosion control applications. To develop the program several sources were consulted on the costs and efficiency rates of feasible alternatives for application in the WAW. A Watershed Management Plan, in Section XV, takes the economic data from runs of the worksheet and applies the most cost-effective practices from that cost table to the NPS problems listed in this section for development of a plan to effectively treat the watershed.

It is anticipated that the WACF, in cooperation with the Kosciusko and Noble County Soil and Water Conservation Districts (SWCDs), will apply to the IDNR, Division of Soil Conservation Lake and River Enhancement Program for watershed land treatment funding for implementation of watershed stabilization.

B. Methods and Materials

Because the WAW is a relatively high quality watershed with very few critical areas the emphasis for NPS pollution control in this project has been toward nonstructural controls. It should be noted that many non structural land treatment controls are implemented for multiple years. The costs presented in this section are annualized costs and applications for funding assistance should bear this in mind.

The costs for each of these practices, structures, and materials was obtained from the Natural Resources Conservation Service (NRCS) sources, Indiana Department of Transportation, Indiana Department of Natural Resources, and from retail suppliers of materials. Some costs listed in the cost analysis were using prices pre-approved by the IDNR, Division of Soil Conservation for watershed land treatment practices. It should be noted that these prices were approved in 1994 and have not been adjusted for inflation. The earliest implementation will be in 1996, therefore, prices should be adjusted accordingly when making applications for funding.

C. Discussion and Summary of Results

Because the non point source loading to the WAW waterways is relatively low, structural controls have been deemed unnecessary over most of the WAW. Structural controls tend to be more expensive to construct, operate, and maintain than nonstructural controls involving farm operation practice modifications and the establishment and maintenance of native vegetative ground covers.

Watershed land treatment also is a better strategy to pull watershed landowners (who are key people to have concerned) and stakeholders into being concerned for the protection of the local aquatic resources. Water quality improvement is difficult to achieve without the cooperation and assistance of local land owners, and farm operators.

For area treatments to reduce sheet erosion, agronomic practices, such as integrated nutrient management, cover crop plantings, crop rotations, contour tilling, and conservation tillage are some of the most cost-effective conservation practices. Filter strips between cropped or grazed fields and waterways is also very cost-effective.

For field gully erosion, grassed waterways are typically the most cost-effective treatment.

For channel bank stabilization and downcutting of stream channels, a combination of biotechnical controls, rip-rap armor, and grade stabilization is the most cost-effective.

Many steep banks can cost-effectively be stabilized by hand-working crown vetch seed into the soil and covering the bank with an erosion control blanket.

As mentioned above, many land treatment strategies involving the subsidizing of a farmer to implement a conservation practice are multiple year contracts. By subsidizing a farmer to convert to a different operation or to implement a new conservation practice, subsidizing for three or more years ensures a much greater chance that the farm operator will continue the practice on his own after funding expires.

In addition to cost sharing with the farmer from 65% to 80% of the allowable cost of implementation of the conservation practice, many times an incentive payment to the farmer is also made. This incentive payment is additional money to entice the farmer to implement the practice. The incentive payment is variable and may not even be necessary in the WAW. The local district conservationists will be able to provide guidance on this issue for specific land treatment efforts. The prices listed below do not include any incentive payments over and above the cost of the practice implementation.

Table 31
Watershed Treatment Cost Feasibility Worksheet
Preliminary Construction Cost Estimates, November 27, 1995

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
0	Mobilization, Bond, etc. (3%)	0					LS	$0.00	$0.00
2	Lake Excavation	0					CYS	$5.00	$0.00
3	Riprap, Hand Laid, 12 In.	0					SYS	$60.00	$0.00
4	Shot Rock (250Lb)	0					CYS	$100.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$18.00	$0.00
6	Seeding, Sodding	0					SF	$2.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$6.86	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$9.87	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$6.95	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$10.03	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$90.35	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	3	2	CYS	$62.73	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	3	1.33	CYS	$53.63	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$0.65	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$0.90	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$1.39	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0	90	7.5		75	SYS	$1.70	$0.00
18	Geotextile FRWTNO312.5 (12.5X360 500 sys)	0	360	12.5		500	SYS	$0.53	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys)	0	360	12.5		500	SYS	$0.58	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys)	0	300	12.5		417	SYS	$0.88	$0.00
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$120.25	$0.00
22	PVC Gabions ERPG12x3x3 (2 sys)	0	12	3	3	2	SYS	$87.50	$0.00
23	PVC Gabions ERPG12x3x3 (1.33 sys)	0	12	3	3	1.33	SYS	$70.53	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$1.03	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$1.95	$0.00
26	Grassed Waterways	0					LF	$4.00	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$90.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.20	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.24	$0.00
31	Fencing (Farm Field)	0					LF	$1.50	$0.00
32	Filter Strip 20' Width (Grass, Legume)	0	2178	20			ACRE	$655.00	$0.00
33	Filter Strip 20' Width (Wooded)	0	2178	20			ACRE	$875.00	$0.00
34	Filter Strip 30' Width (Grass, Legume)	0	1452	30			ACRE	$585.00	$0.00

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
35	Filter Strip 30' Width (Wooded)	0	1452	30			ACRE	$730.00	$0.00
36	Filterstrips 40' Width (Grass, Legume)	0	1089	40			ACRE	$550.00	$0.00
37	Filterstrips 40' Width (Wooded)	0	1089	40			ACRE	$660.00	$0.00
38	Ponds/Wetlands (Excavated)	0					CYS	$2.50	$0.00
39	Wetland Development/Imp (Hydrology alter)	0					ACRE	$400.00	$0.00
40	Sediment Basin (Excavation)	0					CYS	$2.00	$0.00
41	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,500.00	$0.00
42	Conservation Esmnts (Marginal Farmland)	0					ACRE	$500.00	$0.00
43	Conservation Esmnts (Average Farmland)	0					ACRE	$800.00	$0.00
44	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,000.00	$0.00
45	Sed. Excavation to Create Diversion Berms	0					LF	$3.00	$0.00
46	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.11	$0.00
47	Sediment Hauling (2 Mile Round Trip)	0					CYS	$2.65	$0.00
48	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.50	$0.00
49	Sediment Hauling (10 Mile Round Trip)	0					CYS	$6.23	$0.00
50	Filter Fabric	0					SYS	$3.00	$0.00
51	Grade Stabilization Structure	0					EA	$6,000.00	$0.00
52	Livestock Watering Facility	0					Gallon	$0.60	$0.00
53	Waste Management System (Livestock)	0					EA	$20,000.00	$0.00
54	Streambank & Shoreline Protection (rip rap)	0					LF	$25.00	$0.00
55	Streambank Protection Vegetative	0					LF	$2.50	$0.00
56	Streambank Biotechnical (Combination)	0					LF	$7.50	$0.00
57	Integrated Pest Management	0					ACRE	$6.00	$0.00
58	Nutrient Management	0					Soil Sample	$6.00	$0.00
59	Mulch Till	0					ACRE	$8.00	$0.00
60	Conservation Tillage	0					ACRE	$15.00	$0.00
61	Straw Bale Dam (Installed)	0					EA	$25.00	$0.00
62	Pasture and Hayland Planting	0					ACRE	$120.00	$0.00
63	Cover Crops (Wheat)	0					ACRE	$12.00	$0.00
64	Critical Area Planting Shaping	0					ACRE	$400.00	$0.00
65	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$560.00	$0.00
	SUBTOTAL								$0.00
	20% CONTINGENCIES								$0.00
	TOTAL								$0.00

Section XIV

In-Lake Response Models to NPS Pollution Controls

XIV. IN-LAKE RESPONSE MODELS TO NPS POLLUTION CONTROLS

A. Introduction

While Lake Wawasee is not considered to presently be in an advanced eutrophic state, in-lake responses to watershed treatment was modeled to provide an estimate of the marginal in-lake water quality improvement to be expected as a result of implementation of watershed management alternatives.

B. Methods and Materials

By using the lake management industry standard lake response computer model EUTROMOD, different watershed management strategies were modeled to provide an estimate of the in-lake water quality response to the management strategies.

In-lake response models were developed for lakes much more eutrophic than lake Wawasee, where in lake responses to watershed management would be more noticeable in water clarity, an improvement in fisheries, and a change in phytoplankton community composition and concentration.

C. Results and Discussion

Given the existing relatively good overall condition of the WAW, the quality of Lake Wawasee water (low concentrations of Phosphorus), and the volume of the lake, it is difficult to achieve a substantial reduction in phosphorus concentrations from the water column, such that there would be a measurable result from the nutrient reduction.

Table 32
Bonhomme Trophic Index
Indiana Department of Environmental Management

	Wawasee					
	North Basin		South Basin			
	7/3/95	7/20/95	7/3/95	7/20/95	Syracuse (7/20/95)	Bonar (7/3/95)
Total Phosphorus (P) mg/l	<0.03	0.06	<0.03	0.04	0.17	0.07
Ortho Phosphorus (P) mg/l	<0.03	<0.02	<0.03	<0.02	0.11	<0.03
Organic Nitrogen (N) mg/l	0.65	0.60	0.66	0.60	1.10	1.80

	Wawasee					
	North Basin		South Basin			
	7/3/95	7/20/95	7/3/95	7/20/95	Syracuse (7/20/95)	Bonar (7/3/95)
Nitrate Nitrogen (N) mg/l	0.15	<0.10	0.15	<0.10	0.10	<0.10
Ammonia Nitrogen (N) mg/l	0.11	0.37	0.20	0.15	0.22	0.13
Dissolved Oxygen (D.O.) percent saturation	100	100	70	43	100	100
Secchi depth (Feet)	15	>7	14	9	12	10.5
% Light penetration at 3 feet	80	70	>70	70	80	75
Plankton per liter Epilimnion (X 1000)	164	954	143	440	307	190
Plankton per liter Metalimnion (x 1000)	653	2000	717	1400	1700	653
Eutrophy Points	2	12	3	10	10	6

D. Model Responses

The Eutromod model predicts that phosphorus and nitrogen loading under the present land uses are 2600 and 55,000 kg/yr, respectively. These loading estimates are similar to those made by sampling tributaries during this study (see Section VII, Table 10). In addition, the Eutromod model predicts that the largest loading of phosphorus and nitrogen presently originates from agricultural inputs (see attached graphs).

E. The "Wilderness" Alternative

To determine what the Eutromod model would predict for lake quality under the best possible conditions, the watershed was assumed to be converted to an entirely forested wilderness. This assumption resulted in the following predictions (with the present conditions also shown for comparison):

Table 33
"Wilderness Alternative" Nutrient Reduction Estimates

	Present Situation	Converting Watershed to Complete Forest
Phosphorus Loading (kg/yr)	2,600	720
Nitrogen Loading (kg/yr)	55,000	3800
Secchi Depth (Meters)	3.1	3.8
Carlson Trophic Index	49	41
Chlorophyll a (ug/l)	11	5

The model indicates that Lake Wawasee's best possible condition (the entire watershed converted to forested wilderness) would result in large nutrient reductions but considerably smaller changes in water clarity and trophic status. The model predicts that the lake could be about twice as clear as it presently is, but would still fall in the "mesotrophic" range, probably due to its large surface to volume ratio, nutrients stored in the system, and to atmospheric inputs.

F. Effects of Eliminating Septic Tanks

The Eutromod model predicts that septic tank inputs (based on 1400 users in the watershed) account for about 20% of the phosphorus and 9% of the nitrogen loading to Lake Wawasee. If septic tank inputs were completely eliminated from the watershed, the model predicts that nutrient loading to the lake would decline. However, because phosphorus loading is already thought to be in the "acceptable" range as predicted by the Vollenweider model, Eutromod shows that nutrient reductions achieved by eliminating all septic tank inputs in the watershed would have only a small effect on the trophic status and overall clarity of Lake Wawasee (see table below). While always desirable from a lake management standpoint, eliminating all septic tank inputs from this watershed would probably cause only minor improvements in Lake Wawasee water quality.

Table 34
Wastewater Collection and Treatment Alternative Estimated Nutrient Reduction

	Present Situation	Eliminating Septic Tanks
Phosphorus Loading (kg/yr)	2,600	2100
Nitrogen Loading (kg/yr)	55,000	50000
Secchi Depth (Meters)	3.1	3.2
Carlson Trophic Index	49	48
Chlorophyll a (ug/l)	11	10

Section XV

Watershed Management Plan

XV. WATERSHED MANAGEMENT PLAN

A. Prioritization of Sub-Basins

There were five separate drainage sub-basins within the Wawasee Area Watershed (WAW) that were sampled for water quality. Two other sources of nutrients (lake margin runoff and precipitation)were modeled. The first five sub-basins listed below were sampled for water quality coming to Lake Wawasee. Watershed treatment needs are prioritized based on the annual loading of nutrients to Lake Wawasee from the five measured sub-basins, from modeled lake margin areas, and on lake uses.

1. Turkey Creek Sub-Watershed
2. Enchanted Hills Sub-Watershed
3. South Shore Country Club Sub-Watershed
4. Bonar Lake Sub-Watershed
5. Papakeechie \ Tri-County Fish and Wildlife Sub-Watershed
6. Local Lake Margin Runoff
7. Precipitation (not manageable by WACF)
8. On-lake Use (not quantifiable)

This watershed management plan focuses on the first six identified sources of sediment and nutrient inputs to the WAW waterways.

B. Prioritization of Sites Within Sub-Basins

Tables 24 through 30 in Section XI list the priority of "Hotspots" within each subwatershed. Because most of the problem areas were similar in nature and nonpoint source (NPS) potential, they were ranked primarily based on their position in the watershed. The sites nearest waterways were prioritized higher because they have a greater opportunity to impact WAW water quality.

An effort has been made to not pinpoint the individual property identified as a hotspot. To point blame at individual farm operators or landowners could alienate people who are key to the success of the implementation of treatment measures. To avoid accusation and possibly offending key people, the sites for treatment within individual subwatersheds is only listed by the section (square mile) of the hotspot in this report.

Individual on-site planning by local resource agency personnel, who are familiar with local producers, is the most effective way to specifically plan for treatments of individual hotspots.

C. Recommended Pollution Control Alternatives and Associated Costs

Due to the macro planning level of this study, it is necessary to point out that the pollution control alternatives recommended in this section may need to be revised based on micro level on-site planning performed by the coordinator of this watershed land treatment program. To allow each hotspot to be treated on an individual basis, on-site planning with each individual landowner needs to be performed. The result should be specific plans for each farm that fit into the overall management scheme of the farmer. Implementation of conservation practices must not only be inexpensive, but also easy and not time consuming to the farm operator. For this reason there may be other alternative practices or combinations of practices that are actually more effective for a given farm than is suggested in Table 35 below.

For the reasons stated above, the land treatments and conservation practices suggested in Table 35 should be considered loose recommendations as oppose to a strict watershed management plan and not necessarily meant to be a prescription to be followed without flexibility.

Table 31 from Section XIII presents the most cost effective watershed land treatment and structural alternatives for stabilizing the watershed problem areas. However, this table only lists land treatment practice implementation costs. Not all actual costs (such as administrative costs) are listed in Table 31. Table 35, which follows, lists the construction and implementation only costs for the recommended practices for each watershed hotspot.

In addition to construction and implementation costs there are other variable costs associated with the coordination of watershed treatment activities, overhead costs of the coordinator, and incentive payments made to farmers over and above the cost share for implementation of a conservation practice. These costs are widely variable locally and should be added to the total project costs by the coordinator of the land treatment program for the WAW.

Other implementation cost considerations that should be added by the entity or individual responsible for implementation of watershed treatment is multiple year contracts with individual landowners on specific practices and adding inflation into the total project budget.

D. <u>Recommended Course of Action for Watershed Pollution Control Activities</u>

The first order of business for the WACF in stabilizing the WAW would be to get a coordinator of activities in place. This should be very easy for the WACF since the Natural Resource Conservation Service (NRCS) staff of both counties in the WAW, Wayne Stanger of Noble County and Sam St. Clair of Kosciusko County, are experienced in the implementation of watershed land treatment projects, the projects should be very easy to get started and to be carried out. In addition the IDNR Division of Soil Conservation has resource specialists, employed in each of the county offices. It is the charge of the resource specialists to carry out the implementation of the conservation programs in their respective counties. Therefore, appointing one or more watershed coordinators should be an easy task.

The next order of business should be to encourage the organization of another subwatershed task force for the Turkey Creek watershed similar to the Enchanted Hills Watershed Task Force. It is important to bring key landowners into the process and get them to feel a sense of ownership in the project. A popular catch phrase for this process is termed "empowering watershed stakeholders".

The vast majority of watershed treatment needs are located in the two largest subwatersheds. It is, then, assumed that the implementation of these land treatments and structural controls will be performed throughout the entire watershed as one project rather than on a subwatershed basis. Therefore, the planned watershed management strategies have been presented together on Table 35 without subdividing recommended treatment by watershed sub-basins.

All of the watershed treatments recommended for implementation in this watershed management plan have been selected because they can be implemented with little additional planning, without needing to obtain environmental or construction permits, and these treatments can be implemented without expensive engineering design services. In addition, implementation of these strategies will effectively address the vast majority of NPS pollution to the WAW waterways.

Table No. 35
Planned Watershed
Management Strategies

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
1	13-34N-7E	Field erosion in conventional tilled field Launer Ditch grading	2,100 L.F. 5 Acres 187.8 Acres (300 Acres nut/pest man.) 7 shot rock check dams	26 36 or 37 63 57 & 58 4 ($10\ yd^3$ ea.) contour till	$8,400 $2,925[g] - $3,650[w] $2,260 $2,700 $14,000 S.T.*$30,285 - $31,010
2	22-34N-7E	Field erosion on HEL	33 Acres	57 & 58 60 63 contour till	$300 $450 $400 S.T. $1,150
3	28-34N-7E	Field erosion on HEL	33.6 Acres	57 & 58 60 63 contour till	$300 $450 $400 S.T. $1,150

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
4	19-34N-8E	Field erosion near trib ditch to Dillon Crk.	2,200 L.F. 1 Acres 500 Acres 200 Acres 500 L.F. 1 Livestock Waste Management System	26 34 or 35 57 & 58 63 56 53 contour till	\$8,000 \$585[g] - \$730[w] \$4,500 \$2,400 \$5,000 \$20,000 S.T. \$40,485 - \$40,630
5	20-34N-8E	Field & gully erosion near ditch trib to Dillon Crk.	2,200 L.F. 4 Acres 68.6 Acres (500 acres conservation tillage & nut/pest man.)	26 34 or 35 63 57 & 58 60 contour till	\$8,000 \$2,340[g] - \$2,920[w] \$825 \$4,500 \$7,500 S.T. \$23,165 - \$23,745
6	30-34N-8E	Field & Pasture erosion in HEL	2,700 L.F. 3.00 Acres 44.9 Acres (500 acres conservation tillage)	26 36 or 37 57 & 58 60 contour till	\$10,800 \$1,755[g] - \$2,190[w] \$405 \$7,500 S.T. \$20,460 - \$20,895
7	30-34N-8E	Field & Pasture erosion in HEL near Turkey Creek	1.2 Acres	36 or 37 contour till	\$700[g] - \$875[w]

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
8	30-34N-8E	Field erosion near Turkey Creek	400 L.F. 16.1 Acres	26 57 & 58 63 contour till	$1,600 $144 $200 S.T. $1,944
9	5-33N-8E	Field erosion in HEL near ditch which flows to Gordy Lake	1.6 Acres 20.1 Acres	36 or 37 57 & 58 63 contour till	$900[g] - $1,050[w] $180 $240 S.T. $1,320 - $1,470
10	5-33N-8E	Field & Gully erosion next to ditch flowing between Hindman & Gordy Lakes	450 L.F. 8 Acres	26 62 contour till	$1,820 $960 S.T. $2,780
11	32-34N-8E	Field erosion next to ditch flowing to Rider Lake	850 L.F. 2 Acres 30 Acres	26 34 or 35 57 & 58 63 contour till	$3,400 $1,170[g] $1,460[w] $180 $360 S.T. $5,110 - $5,400
12	32-34N-8E	Field & gully erosion next to Duely Lake	650 L.F. 25.1 Acres	26 57 & 58 63 contour till	$2,600 $225 $300 S.T. $3,125
13	32-34N-8E	Field erosion in HEL	600 L.F. 19.4 Acres	26 57 & 58 63 contour till	$2,400 $180 $240 S.T. $2,820
14	28-34N-8E	Field & gully erosion in HEL near ditch trib to Rider Lake	1,400 L.F. 112 Acres	26 57 & 58 63 contour till	$5,650 $1,010 $1,344 S.T. $8,000

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
15	27-34N-8E	Field & gully erosion in HEL	500 L.F. 52.8 Acres	26 57 & 58 63 contour till	$2,100 $480 $640 S.T. $3,220
16	7-33N-8E	Field & gully erosion in HEL near ditch trib to Hindman Lake	700 L.F. 31.2 Acres	26 57 & 58 63 contour till	$2,800 $280 $375 S.T. $3,455
17	8-33N-8E	Field & gully erosion in HEL near ditch trib to Hindman Lake	400 L.F. 2 Acres 31 Acres	26 36 or 37 57 & 58 63 contour till	$1,600 $1,170[g] - $1,460[w] $280 $375 S.T. $3,425 - $3,715 $2,655
18	8-33N-8E	Field erosion in HEL near ditch trib to Hindman Lake	17.6 Acres	57 & 58 63 contour till	$165 $220 S.T. $385
19	4-33N-8E	Field erosion in HEL	18 Acres	57 & 58 63 contour till	$165 $220 S.T. $385
20	3-33N-8E	Field erosion in HEL	2 Acres 52 Acres	36 or 37 57 & 58 63 contour till	$1,170[g] - $1,460[w] $470 $625 S.T. $2,265 - $2,555
21	3-33N-8E	Field erosion in HEL near ditch trib to Harper Lake	3 Acres 21 Acres	36 or 37 57 & 58 63 contour till	$1,755[g] - $2,190[w] $200 $260 S.T. $2,215 - $2,650

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
22	3-33N-8E	Field erosion in HEL near Piper Branch Ditch	3.5 Acres 25 Acres	36 or 37 57 & 58 63 contour till	$2,050[g] - $2,555[w] $225 $300 S.T. $2,575 - $3,080
23	2-33N-8E	Field erosion in HEL near Piper Branch Ditch	3 Acres 11 Acres	36 or 37 57 & 58 contour till	$1,755[g] $2,190[w] $100 $132 S.T. $2,000 - $2,425
24	2-33N-8E	Field erosion in HEL	400 L.F. 27.5 Acres	26 57 & 58 63 contour till	$1,600 $250 $350 S.T. $2,200
25	2-33N-8E	Field erosion in HEL	2 Acres 26.2 Acres	34 or 35 57 & 58 63 contour till	$1,170[g] - $1,460[w] $250 $320 S.T. $1,740 - $2,030
26	11-33N-8E	Field erosion in HEL	400 L.F. 2 Acres 44.5 Acres	26 34 or 35 57 & 58 63 contour till	$1,600 $1,170[g] - $1,460[w] $405 $540 S.T. $3,715 - $4,005

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
27	34-34N-8E	Field erosion in HEL	1.5 Acres 20.2 Acres	34 or 35 57 & 58 63 contour till	$900[g] - $1,100[w] $180 $240 S.T. $1,320 - $1,520
28	3-33N-8E 10-33N-8E	Field erosion in HEL next to Piper Ditch	300 L.F. 2.5 Acres 29.3 Acres	26 34 or 35 57 & 58 63 contour till	$1,200 $1,465[g] - $1,825[w] $270 $360 S.T. $3,300 - $3,655
29	30-34N-8E	Cattle on steep HEL next to Turkey Creek w/ access to Turkey Crk.	400 L.F. 5 Acres	43 31 54 51,52 52	$4,000 $3,000 $10,000 $5,800 $1,000 S.T. $23,800
30	22-34-7E	High S.S. conc. in ditch flowing to Lake Wawasee; S.S. coming from subdivision construction site west of South Shore Country Club	-NA- -NA- -NA- -NA-	29,30 50 51 52	have developer pay
31	8-34N-7E	Construction site erosion	700 L.F. -NA- 700 L.F.	29,30 50 51,52	have builders or property owners pay

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

Problem Number	Location	Description of Problem	Area To Be Treated	Viable Treatment[1]	Cost of Treatment
32	24-34N-7E	High Bacteria Count area within Lake Wawasee	Needs To Be Further Evaluated	-NA-	-NA-
TOTAL					Approx. $200,000 - $210,000

* = S.T. = Subtotal

It may be necessary to purchase buffer strips or obtain a conservation easement on some private land, to install buffer strips. Wetlands can be purchased throughout the watershed and held in conservancy trust to serve as buffer zones.

It may be a better strategy for the WACF to consider purchasing the land with the risk to water quality rather than purchasing a buffer to the risk.

The total listed in Table 35 reflects only the land treatment implementation costs and does not include any costs associated with administration, labor for a coordinator, incentive payments to farmers, permits, or other variable overhead related costs which may be incurred depending on who performs the implementation of the land treatment program.

In Table 35 above, the treatments prescribed for the Enchanted Hills subwatershed were general area treatments similar to what was prescribed in the Enchanted Hills Watershed Evaluation. Since the Enchanted Hills Subwatershed was identified as contributing approximately twice the nutrient and sediment load as the other subwatersheds, on an areal basis, treatments have been prescribed in proportion.

Because the Enchanted Hills Watershed Evaluation was a detailed planning activity this subwatershed was not examined as closely in this project to prevent duplicative efforts. The findings of this project do not counter the findings of the Enchanted Hills Watershed Evaluation. Therefore, it is suggested that the recommendations of the previous Enchanted Hills report be followed.

E. Turkey Creek Subwatershed Implementation

On-site individual farm conservation planning should begin as soon as possible to get a better understanding of what is the most workable solutions for each landowner and to provide more detailed cost estimates for budgetary purposes.

Most of the problems identified in the Turkey Creek subwatershed can be corrected through the installation of grassed waterways, filter strips, and fencing

1 See Watershed Treatment Cost Feasibility Worksheet on Page XIII-2
g Cost using a grassed filter strip
w Cost using a wooded filter strip

livestock out of the stream corridors and away from lake shores. An alternative watering system may need to be provided to livestock producers in specific situations.

Along the east shore of Village Lake is a campground. There does not appear to be a problem with wastewater but it is not known how the wastewater is managed by the campground. In addition, there are cattle grazing on the hillside east of the campground adjacent to Village Lake. The area does not appear overgrazed but the addition of several more head of cattle could result in overgrazing.

The Knapp Lake area needs to be sewered. The Noble County Health Department has responded to numerous complaints of failing septic systems around the developed portions of Knapp Lake. Harper Lake and Little Bause Lake also need to be sewered. A conservancy district or other form of legal entity must be formed to sponsor a wastewater collection, and/ or treatment project for this area. There is a strong likelihood that there will be opposition to the concept of sewering the area, specifically the monthly sewer bill. However, property values should increase substantially, and the community is most likely eligible for Indiana Department of Commerce funding to construct a sanitary sewer system.

On the west shore of Gordy Lake, cattle are grazing in the forested area. This area is not presently overgrazed but the cattle may have access to the water, thus enabling them to introduce manure and urine to the water. The field to the west of Gordy Lake is highly erodible land (HEL) and in conservation reserve program (CRP). As with many other CRP acres around the watershed the CRP contract is about to expire. The land should be re-enrolled in CRP.

F. <u>Enchanted Hills Subwatershed Recommendations for Improvements</u>

As with all agricultural areas of the WAW, all land presently in CRP should be re-enrolled in CRP. Additional candidate acres for CRP should also be identified by the watershed resource agencies and enrolled in CRP.

The agricultural portions of the Enchanted Hills Subwatershed can be stabilized with the addition of contour tilling, channel stabilization, grassed waterways, and filter strips. Since the producer along Launer Ditch and Dillon Creek are producing seed corn they cannot use the chemicals required for no till farming. Based on the parameters this study, a need for structural controls was not confirmed. However, the research done by the joint soil and water conservation districts and the Enchanted Hills Watershed Task Force, was more detailed and recommended several structural controls including the installation of grade stabilization structures in the watershed. Therefore, they are included in the above hotspot treatment table. The use of shot rock check dams should be given strong consideration in this application to reduce costs.

Within the Enchanted Hills subdivision, construction projects need to use best management practices to stabilize soil. Lawns need to be maintained with a thick growth of vegetation without excessive inputs of fertilizers, especially fertilizers containing phosphorus. Lawns can be fertilized at conservative rates with nitrogen fertilizers without causing water quality problems. This can be done by using mulching mowers to mulch grass clippings and leave them on the lawn for fertilizer, using the proper grass seed species most suited to the soil pH, slope and amount of anticipated foot traffic. The pH of lawns should be tested and if they are too acidic for the grass species planted there lime should be applied the adjust soil pH.

Channels banks need to be maintained in a stable state with foot traffic focused on top of maintained foot trails or walkways and concentrated on flatter portions of the banks. Macrophyte management should be performed via harvesting and removing dead plant debris from the water for composting or disposal. Presently the contact herbicide Reward is used for macrophyte control. The following strategies are recommended for specific applications.

1. <u>Channels</u>

    a. Sea walls or retaining walls to stabilize the channel banks. Any type of material including timber would suffice as long as it properly designed.
    b. Walkways to focus foot traffic (decks, paths with shredded bark or stone).
    c. Erosion control measures installed during construction.
    d. Stormwater inlet protection (construction and urban erosion control BMPs) such as straw bale dams and sand bags.
    e. Manual or mechanical harvesting of macrophytes with removal of harvested vegetation from the channels rather than chemical treatment.
    f. Bacteria and dye sampling to determine if a septic leachate problem exists. If so, extend sanitary sewer service to Enchanted Hills.

2. <u>Watershed Stabilization</u>

    a. Stabilize watershed field gully erosion with grassed waterways.
    b. Fence cattle away from ditches and install filter strips between livestock and waterways.
    c. Installation of grassed waterways and filter strip along the ditches in the vicinity of the conventionally tilled cropland.
    d. Stabilization of the tributary ditch banks by biotechnical means and\or stabilize ditch grades with notch-drop grade stabilization structures, located at the ends of straight runs of the ditches.

G. Total Implementation Costs for Selected Hotspot Treatment Alternatives

1. Permits Needed

All of the watershed treatments recommended for implementation in this watershed management plan have been selected because they can be implemented with little additional planning, without environmental or construction permits (except grade stabilization structures in the Enchanted Hills subwatershed), and these treatments can be implemented without expensive engineering design services and expensive construction projects.

For structural pollution control alternatives, the following permits are generally needed:

a. U.S. Army Corps of Engineers, Section 404 Permit
b. IDNR Division of Water, Construction in a Floodway Permit
c. Indiana Department of Environmental Management, 401 Water Quality Certification

2. Funding Sources

The IDNR Division of Soil Conservation, Lake and River Enhancement Program is the most reliable source to fund the implementation phase of this project. Most of the treatments and their associated implementation costs presented in this report have been pre-approved by the IDNR Division of Soil Conservation for funding under the Lake and River Enhancement (LARE) watershed land treatment program.

Following is a funding matrix for watershed protection projects from the Catalog of Federal Watershed Protection Programs.

3. Project Costs To Treat identified Hotspots

Again, it must be pointed out that there are other variable costs specific to individual projects and the overall coordination and implementation of the treatment of the WAW that have not been included in this report. The appointed project coordinator should be charged with generating local specific cost estimates for funding applications.

From Table 35 the total costs to treat identified hotspots in the watershed is $210,000.00 plus as much as an additional $200,000.00 for administration and overhead.

The on-site planning to be performed by local resource agencies will likely identify additional areas to treat any additional operating costs for project implementation.

January 1993

WATERSHED PROTECTION APPROACH FUNDING MATRIX

FUNDING SOURCE [*Catalog of Federal Domestic Assistance Number*]	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
CLEAN WATER ACT (CWA)				
Section 106 Water Pollution Control [66.419]	To administer programs for the prevention, reduction, and elimination of water pollution. State and interstate agencies, Indian tribes.	State targets determined by national formula. Level of effort (LOE) required.	Prevention and abatement of surface and groundwater pollution (permitting, pollution control studies, water quality planning, sampling and monitoring, enforcement, assistance to localities, training, and public information).	FY-93 81.7 FY-92 81.7 FY-91 81.7
Section 604(b) Title VI set-aside Water Quality Management Planning [66.454]	To carry out water quality management planning. State agencies (Planning activities shall involve local, regional, and interstate entities.)	1% of Title VI funds appropriated; $100,000 minimum per state. 40% pass-through to Regional Public Comprehensive Planning Organizations (RPCPOs)/Interstate Organizations (IOs).	Funds can be used to determine the nature, extent, and causes of water quality problems. Funds can be used in identifying cost-effective and locally acceptable facility and nonpoint measures to meet and maintain water quality standards and develop an implementation plan to obtain state and local financial and regulatory commitments to implement such measures	FY-93 20.1 FY-92 19.5 FY-91 20.5
Section 603(d) Revolving Fund Title VI set-aside [66.458]	Water Pollution Control Revolving Fund State agencies	Up to 4% of capitalization grant amount may be used for administering the SRF. Part of capitalization grant—not a separate grant. Title VI allocated by national formula.	Administering the SRF program; financial assistance to any municipality, intermunicipal, interstate, or state agency for construction of publicly owned treatment works.	FY-93 80.5 FY-92 77.9 FY-91 81.9

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE (*Catalog of Federal Domestic Assistance Number*)	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Section 319(h) Nonpoint Source Implementation [66.458]	Implementation of nonpoint source management program. State-designated lead NPS agencies. (In developing and implementing a management program, a state shall, to the maximum extent practicable, involve local public and private agencies.)	Regional targets based on formula including state targets and competitive pool. Approved NPS assessment and management program required. Maintenance of effort (MOE) and 40% match required. Administrative costs are limited to 10% of the amount of the grant. States may use funds from grants made pursuant to this section for financial assistance to persons only to the extent that such assistance is related to the cost of demonstration projects.	Section 319(h) awards fund implementation of approved NPS Management Programs and can be targeted at particular watersheds. Activities can include post-implementation monitoring. A portion of 319(h) grants may be used for groundwater assessment as part of an approved comprehensive NPS pollution control program.	FY-93 50.0 FY-92 52.5 FY-91 51.0
Section 320(g) National Estuary Program [66.456]	Development of comprehensive conservation and management plans for specific estuaries. State, interstate, and regional water pollution control agencies, state coastal zone management agencies, interstate agencies, other public or nonprofit private organizations, individuals.	Funds allocated by formula. Limited to specific estuaries. Grants shall not exceed 75% of the costs of research, survey, studies, and work necessary for the development of CCMPs. The non-federal share of such costs must be provided from non-federal sources.	Planning activities in designated estuaries; implementation precluded by section 320.	FY-93 15.2 FY-92 15.2 FY-91 15.2

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE (*Catalog of Federal Domestic Assistance Number*)	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Near Coastal Waters (66.464)	Improving the environmental conditions of near coastal waters. State water pollution control agencies, interstate agencies, other public or non-profit agencies, institutions, organizations, and individuals.	Assistance awards (i.e., grants and cooperative agreements) using NCW funds require a minimum of 5% non-federal match. Grants awarded under section 104(b)(3).	Implement watershed approach for coastal areas. NCW funds can be used to develop and implement regional strategies that target geographic areas. Activities include identification of problems, identification of appropriate participants, and strategy implementation.	FY-93 [1] FY-92 3.4 FY-91 4.1
State Wetlands Program (66.461)	Grant funds can be used to either (1) develop new wetland protection programs or (2) refine existing wetland protection programs. State agencies administering or developing wetland protection programs, state agencies with wetlands-related programs, and federally-recognized Indian tribes.	States will be expected to provide at least a 25% match for the federal funds awarded through this program. Grants awarded under section 104(b)(3).	State Wetland Conservation Plans, State Section 404 Assumption Assistance, Watershed Protection Approach Demonstration Projects, incorporating wetlands into section 401 programs, streamlining state regulatory programs. (Projects must clearly demonstrate a direct link to increasing a state's ability to protect its wetland resources.)	FY-93 10.0 FY-92 8.5 FY-91 5.0
Assessment and Watershed Protection Support	Assessment and watershed protection support activities can include all levels of government and private organizations	Funds' availability determined annually. Grants in this program are made under the authority of CWA section 104(b)(3). Resources may also be used for IAGs and contract support	FY 1992 guidance highlights watershed planning priorities, including 303(d), general support for watershed approach projects, and Region-wide geographic targeting. FY 1992 guidance emphasizes support for monitoring program priorities, including 305(b) process environmental indicators.	FY-93 [2] FY-92 0.6

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE (*Catalog of Federal Domestic Assistance Number*)	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Water Quality Cooperative Agreements Section 104(b)(3) (66.463)	Unique investigations, special one-time studies, pilots and demonstrations to implement NPDES-related activities. State water pollution control agencies, interstate agencies, other public or non-profit agencies, institutions, organizations, and individuals.	Regional targets based on formula. No state funding targets. Regional selection of projects. No match required 1- to 2-year demonstration-type projects. Not for continuing program operation.	Support implementation of NPDES program: combined sewer overflow/stormwater discharge control programs (develop stormwater permit program, develop and implement BMPs for stormwater demonstration of innovative CSO controls, development of permit conditions for CSO systems).	FY-93 16.5 FY-92 16.5 FY-91 16.5
Regional Initiatives	No limitations on potential participants	A relatively new process allowing Regions to develop individual initiatives within the framework of the annual budget process.	All phases of a watershed protection project can be supported.	FY-93 4.0
Wetlands Protection Program	Wetlands protection activities can involve other federal agencies, state agencies, and local groups, including agricultural groups.	Grants in this program can be made under the authority of CWA section 104(b)(3). Resources may also be used for IAGs and contract support.	Funds can be used to provide technical assistance on effective river corridor/watershed management planning. Wetlands protection funds can be used for activities involving targeted watersheds such as advance identification, targeted section 404 enforcement actions, and education/outreach programs Funds can be used for section 404 compliance monitoring programs for specific priority watersheds.	FY-93 [5] FY-92 4.2

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE (*Catalog of Federal Domestic Assistance Number*)	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Section 314(b) Clean Lakes (66.435)	To prepare identification and classification surveys of all publicly-owned lakes; to establish methods and procedures to control sources of pollution and restore the quality of such lakes. Grants are provided to states. (Historically, participants in Clean Lakes projects have represented various levels of both public and private sectors.)	30% match for Phase I — diagnostic/feasibility. (Not to exceed $100,000.) 50% match for Phase II — restoration, assessment. (Priority consideration given to projects that show a commitment to program integration.) 30% match for Phase III — post-restoration monitoring. (Not to exceed $125,000.)	Lake Water Quality Assessment (LWQA) — funds are to compile a comprehensive, statewide assessment of lake water quality, to enhance overall state lake management programs, and to increase public awareness and commitment to preserving lakes. Diagnostic/Feasibility Study — funds are provided to perform a comprehensive study of a particular lake and its watershed. Funds can be used to evaluate possible solutions and recommend restoration and protection methods. (Phase I) Restoration/Protection Implementation Project — funds are provided to implement recommended in-lake techniques and watershed management practices. (Phase II) Post-Restoration Monitoring — funds are provided to determine effectiveness of various restoration techniques. (Phase III)	FY-93 4.0 FY-92 7.0 FY-91 7.0
Congressional Appropriation Add-ons	No limitations on potential participants. Participants are often determined by appropriations language.	Appropriations language may or may not impose specific restrictions on how resources may be spent (e.g., through grants, contracts, etc.).	No limitations on potential activities. Activities are generally determined by appropriations language.	FY-93 46.9 [4]

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE [*Catalog of Federal Domestic Assistance Number*]	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Section 104(g) Operator Training	To provide an adequate supply of trained personnel to operate and maintain existing and future treatment works. State and interstate agencies, municipalities, and educational institutions.	State allocation by performance. Congressional add-on to budget. 25% match required.	Training projects, technical assistance for publicly owned treatment works operators.	FY-93 0.8 FY-92 2.0 FY-91 1.8
Section 104(g) Small Community Outreach	Incentive grants to develop or expand small community outreach programs. State agencies, nonprofit agencies, universities, water research institutes, Indian tribes.	Regional allocation. Competition within Region. 50% match of the requested federal amount.	Intended to encourage the establishment or enhancement of state small community outreach programs.	FY-93 0.2 FY-92 0.0 FY-91 0.15
SAFE DRINKING WATER ACT				
Section 1443(a)(1) Public Water System Supervision [66.432]	To carry out public water system supervision programs. State agencies, Indian tribes.	State targets determined by national formula. States must have primacy. 25% match required.	Public water system supervision; state drinking water programs (program costs, technical assistance, lab capability, enforcement, data management).	FY-93 58.9 FY-92 50.0 FY-91 47.8
Section 1443(b) Underground Injection Control [66.433]	To carry out underground injection control program. State agencies, Indian tribes.	State targets determined by national formula. States must have primacy. 25% match required.	Underground injection control programs (program costs, inventories, data management, technical assistance).	FY-93 10.5 FY-92 10.5 FY-91 10.5

WATERSHED PROTECTION APPROACH FUNDING MATRIX (CONTINUED)

FUNDING SOURCE [*Catalog of Federal Domestic Assistance Number*]	FUNDING PURPOSE/ ELIGIBLE RECIPIENTS	ALLOCATION METHOD/ CONDITIONS/LIMITATIONS	ELIGIBLE ACTIVITIES (Examples)	FUNDING AVAILABLE ($ Million)
Section 1442(b) Wellhead Protection (WHP)	Demonstration projects aimed at assisting municipalities to design and implement a wellhead protection program. Municipalities, as defined under the SDWA, meaning cities, towns, or other public bodies created by or pursuant to state law, or Indian tribes.	Regional allocation. Competitive process within Region. 5% match required.	Delineation of WHP areas; identification of sources of contamination; public education; development of ordinances for WHP; WHP contamination source surveys; GIS mapping of WHP areas.	FY-93 0.0 FY-92 1.5 FY-91 1.5

[1]Total regional allocation of FY93 Near Coastal Waters funds has not yet been determined, pending final operating plan.

[2]Total Regional allocation of FY93 Assessment and Watershed Protection funds has not yet been determined, pending final operating plan.

[3]Total Regional allocation of FY93 Wetlands Protection funds has not yet been determined, pending final operating plan.

[4]OW AC&C add-ons. (Does not include Congressional add-ons for Clean Lakes and NPS Grants.)

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